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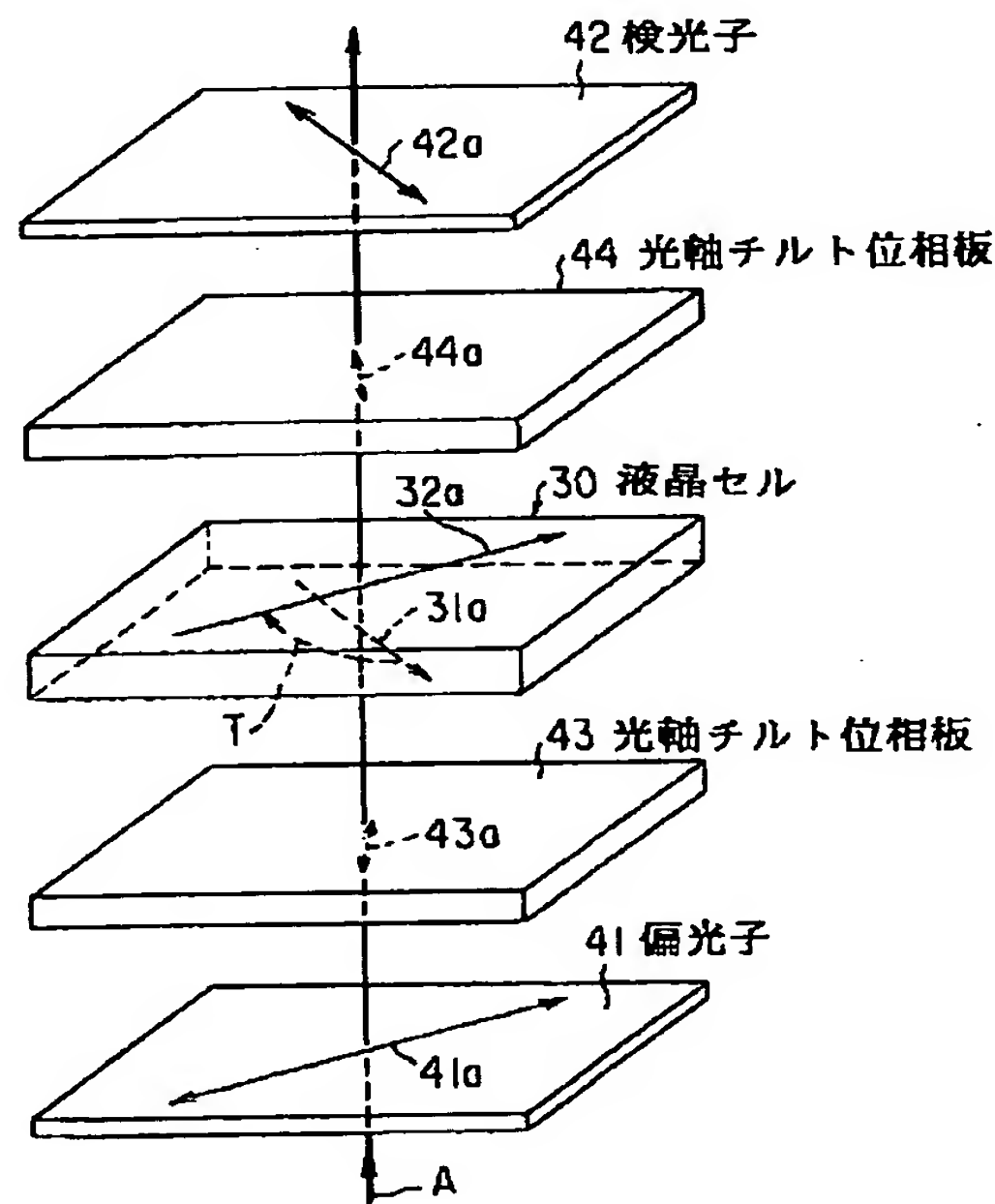
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(54)【発明の名称】 液晶表示装置

(57)【要約】

【目的】TN型の液晶セルを用いた液晶表示装置の視野角を広くし、かつ、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもなくして“ちらつき”や階調の反転のない高品質の表示を得る。

【構成】TN型液晶セル30と偏光子との間および前記液晶セル30と検光子42との間にそれぞれ厚さ方向に遅相軸43a、44aをもちかつこの遅相軸が法線に対し所定角度斜めにチルトした光軸チルト位相板43、44を配置し、入射側光軸チルト位相板43の法線に対する遅相軸のチルト方向を、液晶セル30の入射側基板31上の配向処理方向31aとほぼ直交させ、出射側光軸チルト位相板44の法線に対する遅相軸のチルト方向を、液晶セル30の出射側基板32上の配向処理方向32aとほぼ直交させた。



【特許請求の範囲】

【請求項 1】透明電極と液晶分子の配向方向を規制する配向膜を積層した一対の透明基板間にネマティック液晶を封入しツイスト配列させた液晶セルの入射側に偏光子を配置し、前記液晶セルの出射側に検光子を配置するとともに、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に遅相軸をもちかつこの遅相軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を配置してなり、

前記偏光子はその透過軸を前記液晶セルの入射側基板上の配向膜に施した配向処理の方向とほぼ直交させるかあるいはほぼ平行にして配置され、前記検光子はその透過軸を前記偏光子の透過軸とほぼ直交させるかあるいはほぼ平行にして配置されているとともに、前記光軸チルト位相板は、その法線に対する遅相軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板上の配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されていることを特徴とする液晶表示装置。

【請求項 2】光軸チルト位相板は、液晶セルと偏光子との間と、前記液晶セルと検光子との間の両方にそれぞれ設けられており、この両光軸チルト位相板は、その法線に対する遅相軸のチルト方向を互いにほぼ直交させて配置されていることを特徴とする請求項 1 に記載の液晶表示装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は TN 型の液晶セルを用いた液晶表示装置に関するものである。

【0002】

【従来の技術】液晶表示装置としては、一般に、TN（ツイステッド・ネマティック）型の液晶セルを用いたものが利用されている。図 24 および図 25 は従来の液晶表示装置の分解斜視図および断面図であり、この液晶表示素子は、TN 型液晶セル 10 と、この液晶セル 10 への光 A の入射側に配置された偏光子 21 と、前記液晶セル 10 の出射側に配置された検光子 22 とで構成されている。

【0003】上記液晶セル 10 は、図 25 に示すように、ガラス等からなる一対の透明基板 11、12 をその周縁部において枠状のシール材 17 を介して接合し、この両基板 11、12 間のシール材 17 で囲まれた領域に液晶 18 を封入したもので、両基板 11、12 の互に対向する面にはそれぞれ液晶層に電界を印加するための透明電極 13、14 が形成されており、その上に、液晶分子の配向方向を規制する配向膜 15、16 が形成されている。

【0004】そして、上記配向膜 15、16 による液晶分子に対する配向規制方向は互いにほぼ 90° ずれており、液晶分子は、これら配向膜 15、16 により、その

膜面に対しあるプレチルト角をもった状態で一方向に配向され、両基板 11、12 間においてほぼ 90° のツイスト角でツイスト配列している。

【0005】すなわち、図 24 において、11a は液晶セル 10 の入射側基板 11 上（配向膜 15 面）における液晶分子配向方向、12a は出射側基板 12 上（配向膜 16 面）における液晶分子配向方向、T は液晶分子のツイスト方向を示しており、液晶分子は、入射側基板 11 から出射側基板 12 に向かって、図上右回りにほぼ 90° のツイスト角でツイスト配列している。なお、上記液晶セル 10 としては、一般に、液晶 18 の屈折率異方性 Δn と液晶層厚 d との積 $\Delta n \cdot d$ の値が 350 ~ 450 nm のものが使用されている。

【0006】一方、図 24 において、21a は偏光子 21 の透過軸、22a は上記検光子 22 の透過軸を示しており、偏光子 21 は、その透過軸 21a を液晶セル 10 の入射側基板 11 上における液晶分子配向方向 11a とほぼ直交させるかあるいはほぼ平行にして配置され、検光子 22 は、その透過軸 22a を前記偏光子 21 の透過軸 21a とほぼ直交させるかあるいはほぼ平行にして配置されている。

【0007】なお、TN 型液晶セルを用いる液晶表示装置には、ポジ表示タイプのものとネガ表示タイプのものがあり、ポジ表示タイプの液晶表示装置では図 24 のように、偏光子 21 と検光子 22 とをその透過軸 21a、22a を互いにほぼ直交させて配置し、ネガ表示タイプの液晶表示装置では、偏光子 21 と検光子 22 とをその透過軸 21a、22a を互いにほぼ平行にして配置している。

【0008】上記液晶表示装置は、液晶セル 10 の電極 13、14 間に電圧を印加することによりその電極間の液晶層に電界を印加して表示駆動されるもので、電極 13、14 間に OFF 電圧を印加したとき、つまり液晶分子の配列状態が初期のツイスト配列状態にあるときは、偏光子 21 を通って液晶セル 10 に入射した直線偏光がその偏光方向をほぼ 90° 旋回されて検光子 22 に入射する。

【0009】また、液晶セル 10 の電極 13、14 間に ON 電圧を印加すると、液晶分子が初期のツイスト配列状態からツイスト配列状態を保ちつつ立ち上がって液晶層での旋回作用が小さくなってゆき、液晶分子がほぼ直立状態に立ち上がり配列すると、液晶層での旋回作用がほとんど 0 となり、偏光子 21 を通って入射した直線偏光がその偏光状態のまま液晶セルを通して検光子 22 に入射する。

【0010】このため、例えば偏光子 21 と検光子 22 の透過軸 21a、22a を互いにほぼ直交させているポジ表示タイプの液晶表示装置では、液晶セル 10 の電極 13、14 間に OFF 電圧を印加すると、この部分を通った光のほとんどが検光子 22 を透過して表示が明状態

になり、液晶分子がほぼ直立状態に立上がり配列するON電圧を印加すると、この部分を通った光のほとんどが検光子22で吸収されて表示が暗状態になる。

【0011】また、液晶分子が初期のツイスト配列状態と直立配列状態との中間の状態に配向するON電圧を印加すると、この部分を通った光の一部が検光子22で吸収され、他の光は検光子22を透過して、表示の明るさが明状態と暗状態との中間の階調になる。

【0012】なお、上記液晶表示装置には、一方の基板に表示パターンに対応する形状のセグメント電極を形成し他方の基板に前記セグメント電極と対向するコモン電極を形成したセグメント方式の液晶セルを用いるものと、一方の基板に複数の走査電極を互いに平行に形成し他方の基板に前記走査電極と直交させて複数の信号電極を形成した単純マトリックス方式の液晶セルを用いるものと、一方の基板に複数の画素電極とその能動素子（例えば薄膜トランジスタ等）を行方向および列方向に配列形成し他方の基板に対向電極を形成したアクティブマトリックス方式の液晶セルを用いるものがある。

【0013】

【発明が解決しようとする課題】ところで、上記TN型液晶セルを用いた液晶表示装置は、明状態の表示が非常に明るく、また暗状態の表示が、漏光がほとんどない“黒”に近い表示であるため、コントラスト（明暗比）の高い表示が得られるが、その反面、表示を良好なコントラストで見ることができる視角範囲（以下、視野角という）が狭いという問題をもっている。

【0014】従来の液晶表示装置の視野角を、液晶セル10の両基板11、12上における液晶分子配向方向11a、12aと偏光子21の透過軸21aおよび検光子22の透過軸22aとが図24に示した方向にある液晶表示装置について説明すると、この液晶表示装置における視角（画面に垂直な線に対する角度）およびその方位と表示のコントラストCRとの関係は図26に示したようになる。なお、この液晶表示装置における液晶セル10の $\Delta n \cdot d$ の値は380nmである。

【0015】図26において、複数の同心円は視角を示しており、円の中心は視角0°（画面に垂直）、各円上の視角は中心側から順に、10°、20°、30°、40°、50°である。また視角50°の円の周囲に付した角度値は方位を示しており、上記液晶表示装置では、液晶セル10の入射側基板11上の配向処理方向11aが方位0°の方向にあり、出射側基板12上の配向処理方向12aが方位90°の方向にある。なお、偏光子21の透過軸21aは方位90°と270°の方向、検光子22の透過軸22aは方位0°と180°の方向にある。

【0016】そして、上記液晶表示装置においては、コントラストCRの値が、図26のように、実線で示したコントラスト分布線上においてCR=10、点線で示し

たコントラスト分布線上においてCR=50、破線で示したコントラスト分布線上においてCR=100、二点鎖線で示したコントラスト分布線上においてCR=200であり、例えばCR=200のコントラストが得られる視角が、表示を画面の下縁中央方向（方位315°の方向）から見たときで約32°である。

【0017】なお、上記液晶表示装置の表示を画面の上縁方向（方位135°の方向）から見たときの視角は、CR=200のコントラストが得られる視角は約8°と小さいが、液晶表示装置の表示は、一般に、画面に対して正面方向（法線方向）または画面の下縁方向から観察されるのが普通であり、画面の上縁方向から観察されることはほとんどないため、画面の上縁方向から見たときの視野角が小さくても特に問題はない。

【0018】しかし、従来の液晶表示装置は、画面の下縁中央方向から見たときのCR=200のコントラストが得られる視角は約32°と十分大きいですが、斜め方向から見ると、例えば下縁中央方向に対して45°の方向（方位0°および方位270°の方向）から見たときにCR=200のコントラストが得られる視角が約17°と小さくなり、したがって、表示を良好なコントラストで見ることができる視野角が狭い。

【0019】しかも、上記液晶表示装置は、画面をある方向から大きな視角で見たときの印加電圧の変化に対する明るさの変化が、ある電圧範囲において逆になってしまうという問題ももっている。

【0020】すなわち、図27～図29は、液晶セル10の両基板11、12上の配向処理方向11a、12aと偏光子21の透過軸21aおよび検光子22の透過軸22aとが図24に示した方向にある従来の液晶表示装置の液晶セル10への電極間印加電圧（実効電圧）と表示の明るさ（Y値）との関係を、0°、10°、20°、30°、40°、50°の各視角について調べた結果を示す電圧-明るさ特性図であり、図27は135°の方位から表示を見たときの特性、図28は315°の方位から表示を見たときの特性を示している。なお、225°の方位から表示を見たときの電圧-明るさ特性は図29とほぼ同じである。

【0021】この図27～図29のように、上記液晶表示装置は、画面の上縁方向（方位135°の方向）および左右方向（方位225°の方向と方位45°の方向）から見たときの電圧-明るさ特性には特に問題はないが、画面の下縁方向（方位315°の方向）から見たときの電圧-明るさ特性（図28の特性）が、視角が40°より大きくなると表示の明るさが一旦暗状態になった後2～4vの印加電圧において再び若干明るくなり、それより印加電圧を高くすると再度暗状態になるという、いわゆる“バンプ”をもった特性になる。

【0022】そして、液晶表示装置の駆動電圧は一般

に、視角 0° での電圧-明るさ特性に基づいて設定されているが、上記のような電圧-明るさ特性をもつ液晶表示装置では、視角 0° で表示を見たときの明るさが最大となる電極間電圧が $0\sim$ 約 1.5 v 、明るさがほぼ

“0”になる電極間電圧が約 $3.5\sim 4\text{ v}$ であり、したがってこの液晶表示装置は、電極間電圧の最小値が $0\sim$ 約 1.5 v 、最大値が約 $3.5\sim 4\text{ v}$ となるように駆動電圧を制御して駆動されるため、上記電圧-明るさ特性の“バンプ”は、液晶表示装置の駆動電圧の範囲内において発生する。

【0023】このため、従来の液晶表示装置は、画面をある向から大きい視角で見たときに、暗状態の表示に“ちらつき”が生じるし、また、階調表示においては、暗階調の表示に階調の反転が生じていた。

【0024】本発明は、TN型の液晶セルを用いたものでありながら、その視野角を広くすることができるとともに、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもない、“ちらつき”や階調の反転のない高品質の表示を得ることができる液晶表示装置を提供することを目的としたものである。

【0025】

【課題を解決するための手段】本発明の液晶表示装置は、透明電極と液晶分子の配向方向を規制する配向膜を積層した一対の透明基板間にネマティック液晶を封入しツイスト配列させた液晶セルの入射側に偏光子を配置し、前記液晶セルの出射側に検光子を配置するとともに、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に遅相軸をもちかつこの遅相軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を配置してなり、前記偏光子はその透過軸を前記液晶セルの入射側基板の配向膜に施した配向処理の方向とほぼ直交させるかあるいはほぼ平行にして配置され、前記検光子はその透過軸を前記偏光子の透過軸とほぼ直交させるかあるいはほぼ平行にして配置されているとともに、前記光軸チルト位相板は、その法線に対する遅相軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板の配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されていることを特徴とするものである。

【0026】本発明の一実施態様としては、光軸チルト位相板を、液晶セルと偏光子との間と、前記液晶セルと検光子との間の両方にそれぞれ設け、この両光軸チルト位相板を、その法線に対する遅相軸のチルト方向を互いにほぼ直交させて配置することが考えられる。

【0027】

【作用】本発明の液晶表示装置は、上記液晶セルの電極間に電圧を印加することによって表示駆動されるもので、液晶セルの電極間にOFF電圧を印加したとき、つまり液晶セルの液晶分子の配列状態が初期のツイスト配列状態にあるときは、偏光子を通して入射した直線偏光

が、液晶セルにより偏光方向をほぼ 90° 旋回されて検光子に入射する。

【0028】また、液晶セルの電極間にON電圧を印加すると、液晶分子が初期のツイスト配列状態からツイスト配列状態を保ちつつ立ち上がって液晶層での旋回作用が小さくなってゆき、液晶分子がほぼ直立状態に立ち上がり配列すると、液晶層での旋回作用がほとんど0となり、偏光子を通して入射した直線偏光がその偏光状態のまま液晶セルを通して検光子に入射する。

10 【0029】このため、この液晶表示装置においても、両液晶セルの電極間に印加する電圧に応じて、両液晶セルを通った光が検光子を透過するかあるいは検光子で吸収され、明暗による表示が得られる。

【0030】そして、この液晶表示装置においては、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に遅相軸をもちかつこの遅相軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を設け、かつ、この光軸チルト位相板を、その法線に対する遅相軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板上における液晶分子配向方向とほぼ直交させるかあるいはほぼ平行にして配置しているため、この光軸チルト位相板によって視野角と電圧-明るさ特性が補償され、視野角が広くなるとともに、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもなくなる。

【0031】

【実施例】以下、本発明の一実施例を図1～図23を参照して説明する。図1および図2は液晶表示装置の分解斜視図および断面図である。この液晶表示素子は、TN型液晶セル30と、偏光子41および検光子42と、2枚の光軸チルト位相板43、44とで構成されており、偏光子41は液晶セル30の入射側に配置され、検光子42は液晶セル30の出射側に配置され、また第1の光軸チルト位相板（以下、入射側光軸チルト位相板という）43は液晶セル30と偏光子41との間に設けられ、第2の光軸チルト位相板（以下、入射側光軸チルト位相板という）44は液晶セル30と検光子42との間に設けられている。

【0032】上記液晶セル30は、図2に示すように、ガラス等からなる一対の透明基板31、32をその周縁部において枠状のシール材37を介して接合し、この両基板31、32間のシール材37で囲まれた領域に液晶38を封入したもので、両基板31、32の互いに対向する面にはそれぞれ液晶層に電界を印加するための透明電極33、34が形成されており、その上に、液晶分子の配向方向を規制する配向膜35、36が形成されている。

【0033】なお、上記配向膜35、36は、ポリイミド等の水平配向剤からなる水平配向膜であり、基板上に水平配向剤膜を形成してその膜面を一方向にラビングし

たラビング処理膜か、あるいは基板上にLB（ラングミューア・プロジェクト）法により単分子膜を積層して形成されたLB膜である。

【0034】この配向膜35、36に施した配向処理方向（ラビング処理膜ではラビング方向、LB膜では単分子の並び方向）は互いにほぼ90°ずれており、液晶分子は、これら配向膜35、36により、その膜面に対しあるプレチルト角をもった状態で一方向に配向され、両基板31、32間においてほぼ90°のツイスト角でツイスト配列している。

【0035】すなわち、図1において、31a、32aは液晶セル30の両基板31、32上における液晶分子配向方向、Tは液晶分子ツイスト方向を示しており、液晶分子は、入射側基板31から出射側基板32に向かって、図上右回りにほぼ90°のツイスト角でツイスト配列している。

【0036】この液晶セル30の液晶分子がツイスト配向している状態における垂直入射光に対する $\Delta n \cdot d$

（液晶38の屈折率異方性 Δn と液晶層厚 d との積）の値は、300～600nmである。なお、この液晶セル30は、セグメント方式のものでも、単純マトリックス方式のものでも、またアクティブマトリックス方式のものでもよい。

【0037】一方、図1において、41aは偏光子41の透過軸、42aは検光子42の透過軸を示しており、この実施例では、偏光子41を、その透過軸41aを液晶セル30の入射側基板31上における液晶分子配向方向31aとほぼ直交させて配置している。

【0038】また、この実施例の液晶表示装置は、ポジ表示タイプのものであり、上記検光子42は、その透過軸42aを上記偏光子41の透過軸41aとほぼ直交させて配置されている。

【0039】次に、上記光軸チルト位相板43、44について説明する。この光軸チルト位相板43、44は、例えば分子配列方向を規定した液晶ポリマーからなり、その厚さ方向に遅相軸をもちかつこの遅相軸が法線に対し所定角度斜めにチルトしている。

【0040】図3は上記光軸チルト位相板43、44の遅相軸と進相軸の方向を示す斜視図であり、遅相軸 $Z n_e$ は、位相板面の法線 z に対して所定方向 x に所定のチルト角 θ だけ傾いており、進相軸 $X n_o$ は遅相軸 $Z n_e$ と直交する方向にある。なお、前記遅相軸 $Z n_e$ のチルト角 θ は、0°より大きく90°より小さい値であり、 $\theta = 0^\circ$ の位相板は法線 z 上に遅相軸がある垂直位相板、 $\theta = 90^\circ$ の位相板は法線 z と直交する方向に遅相軸がある通常の位相板である。

【0041】この光軸チルト位相板43、44は、遅相軸 $Z n_e$ 方向における光の屈折率 n_e と、進相軸 $X n_o$ 方向における光の屈折率 n_o とによって決まる屈折率異方性 $\Delta n'$ （ $\Delta n' = n_e - n_o$ ）をもっており、この

光軸チルト位相板43、44の屈折率異方性 $\Delta n'$ と位相板厚 d' との積 $\Delta n' \cdot d'$ の値は、-300～300nmである。なお、この実施例では、光軸チルト位相板43、44の進相軸 $X n_o$ 方向における屈折率 n_o を1.581nmとし、遅相軸 $Z n_e$ 方向における屈折率 n_e を調整して所望の $\Delta n' \cdot d'$ を得ている。

【0042】そして、この光軸チルト位相板43、44はそれぞれ、その法線 z に対する遅相軸 $Z n_e$ のチルト方向を、液晶セル30の前記光軸チルト位相板43、44が隣接する基板上的配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されている。

【0043】すなわち、液晶セル30と偏光子41との間に設けた入射側光軸チルト位相板43は、その法線 z に対する遅相軸 $Z n_e$ のチルト方向を、液晶セル30の入射側基板31上の配向処理方向31aとほぼ直交させるかあるいはほぼ平行にして配置されており、液晶セル30と検光子42との間に設けた出射側光軸チルト位相板44は、その法線 z に対する遅相軸 $Z n_e$ のチルト方向を、液晶セル30の出射側基板32上の配向処理方向32aとほぼ直交させるかあるいはほぼ平行にして配置されており、この両光軸チルト位相板43、44の遅相軸 $Z n_e$ のチルト方向は互いにほぼ直交している。

【0044】この液晶表示装置は、液晶セル30の電極33、34間に電圧を印加することによって表示駆動されるもので、液晶表示装置に入射する光（例えばバックライトからの光）Aは、偏光子42を通過して直線偏光となり、入射側光軸チルト位相板43と、液晶セル30と、出射側光軸チルト位相板44とを通過して検光子42に入射する。

【0045】そして、液晶セル30の電極33、34間にOFF電圧を印加したとき、つまり液晶セル30の液晶分子の配列状態が初期のツイスト配列状態にあるときは、偏光子42を通過して入射した直線偏光が、液晶セル30により偏光方向をほぼ90°旋回されて検光子42に入射する。

【0046】また、液晶セル30の電極33、34間にON電圧を印加すると、液晶分子が初期のツイスト配列状態からツイスト配列状態を保ちつつ立ち上がって液晶層での旋回作用が小さくなってゆき、液晶分子がほぼ直立状態に立ち上がり配列すると、液晶層での旋回作用がほとんど0となり、偏光子41を通過して入射した直線偏光がその偏光状態のまま液晶セル30を通過して検光子42に入射する。

【0047】このため、上記のように偏光子41と検光子42の透過軸41a、42aを互いにほぼ直交させているポジ表示タイプの液晶表示装置では、液晶セル30の電極33、34間にOFF電圧を印加すると、この部分を通った光のほとんどが検光子42を透過して表示が明状態になり、両液晶セル30の電極33、34間に液晶分子がほぼ直立状態に立ち上がり配列するON電圧を印

加すると、この部分を通った光のほとんどが検光子42で吸収されて表示が暗状態になる。

【0048】また、液晶セル30の電極33、34間に液晶分子が初期のツイスト配列状態と直立配列状態との中間の状態に配向するON電圧を印加すると、この部分を通った光の一部が検光子42で吸収され、他の光は検光子42を透過して、表示の明るさが明状態と暗状態との中間の階調になる。

【0049】そして、この液晶表示装置においては、液晶セル30と偏光子41との間および、前記液晶セル30と検光子42との間にそれぞれ、厚さ方向に遅相軸 Z_{ne} をもちかつこの遅相軸 Z_{ne} が法線 z に対してチルトした光軸チルト位相板43、44を設け、かつ、入射側チルト位相板43はその遅相軸 Z_{ne} のチルト方向を液晶セル30の入射側基板31上における液晶分子配向方向31aとほぼ直交させるかあるいはほぼ平行にして配置し、出射側光軸チルト位相板44はその遅相軸 Z_{ne} のチルト方向を液晶セル30の出射側基板32上の配向処理方向32aとほぼ直交させるかあるいはほぼ平行にして配置するとともに、この両光軸チルト位相板43、44の遅相軸 Z_{ne} のチルト方向を互いにほぼ直交させているため、これら光軸チルト位相板43、44によって液晶表示装置の視野角と電圧-明るさ特性が補償され、視野角が広くなるとともに、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもなくなる。

【0050】上記光軸チルト位相板43、44による視野角と電圧-明るさ特性の改善は、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値と遅相軸チルト方向とに応じて遅相軸チルト角 θ を適切に設定することによって達成できる。以下に、その具体的な実施例を説明する。

【0051】【具体例1】この例は、液晶セル30の $\Delta n \cdot d$ の値を380nm、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値を-50nmとし、入射側および出射側の光軸チルト位相板43、44をそれぞれ、その遅相軸チルト方向を液晶セル30の入射側および出射側基板31、32上の各配向処理方向31a、32aと平行にして配置した例であり、光軸チルト位相板43、44の各遅相軸 Z_{ne} のチルト角 θ を40°とする。

【0052】図4は、この液晶表示装置における視角およびその方位と表示のコントラストCRとの関係を示している。図4において、複数の同心円は視角を示しており、円の中心は視角0°（画面に垂直）、各円上の視角は中心側から順に、10°、20°、30°、40°、50°である。また、視角50°の円の周囲に付した角度値は方位を示しており、この液晶表示装置では、液晶セル30の入射側基板31上の配向処理方向31aが方位0°の方向、出射側基板32上の配向処理方向32aが方位90°の方向にある。なお、偏光子41の透過軸41aは方位90°の方向にあり、検光子42の透過軸

42aは方位0°の方向にある。

【0053】また、図4において、43xは入射側光軸チルト位相板43の遅相軸 Z_{ne} のチルト方向、44xは出射側光軸チルト位相板44の遅相軸 Z_{ne} のチルト方向を示しており、入射側光軸チルト位相板43の遅相軸チルト方向43xは方位0°の方向、すなわち液晶セル30の入射側基板31上の配向処理方向31aと同方向（平行でかつ同じ向き）にあり、出射側光軸チルト位相板44の遅相軸チルト方向44xは方位270°の方向、すなわち液晶セル30の出射側基板32上の配向処理方向32aと逆方向（平行でかつ逆向き）にある。

【0054】この図4と、従来の液晶表示装置の視角およびその方位と表示のコントラストCRとの関係を示した図26とを比較して見れば分かるように、上記【具体例1】の液晶表示装置は、例えばCR=200のコントラストが得られる視角が、画面の下縁中央方向（方位315°の方向）から見たときで約27°、下縁中央方向に対して45°の方向（方位0°および方位270°の方向）から見たときで約32°と十分大きく、従来の液晶表示装置に比べて、表示を良好なコントラストで見ることができる視野角がほぼすべての方位で広い。

【0055】なお、この液晶表示装置も、画面の上縁方向（方位135°の方向）から見たときの視野角は従来の液晶表示装置とほとんど変わらないが、【発明が解決しようとする課題】の項でも説明したように、液晶表示装置の表示は、画面に対して正面方向（法線方向）または画面の下縁方向あるいは左右方向から観察されるのが普通であり、画面の上縁方向から観察されることはほとんどないため、画面の上縁方向から見たときの視野角が小さくても特に問題はない。

【0056】また、図5～図7は、上記【具体例1】の液晶表示装置の液晶セル10への電極間印加電圧（V）と表示の明るさ（Y値）との関係を、0°、10°、20°、30°、40°、50°の各視角について調べた結果を示す電圧-明るさ特性図であり、図5は表示を135°の方位から表示を見たときの特性、図6は315°の方位から見たときの特性、図7は45°の方位から見たときの特性を示している。なお、225°の方位から見たときの電圧-明るさ特性は図7とほぼ同じである。

【0057】この図5～図7と、従来の液晶表示装置の電圧-明るさ特性を示した図23～図25とを比較して見れば分かるように、従来の液晶表示装置では、画面の下縁方向（方位315°の方向）から見たときの電圧-明るさ特性（図24の特性）に“バンプ”が生じるが、上記【具体例1】の液晶表示装置は、画面の上縁方向（方位135°の方向）見たときの電圧-明るさ特性（図5の特性）も、画面の左右方向（方位225°の方向と方位45°の方向）から見たときの電圧-明るさ特性（図7の特性）も、画面の下縁方向（方位315°の

方向) から見たときの電圧-明るさ特性 (図6の特性) も、全て“バンプ”のない特性であり、したがって、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

【0058】なお、この例では、光軸チルト位相板43, 44の遅相軸チルト角 θ を 40° としたが、上記のように光軸チルト位相板43, 44の $\Delta n' \cdot d'$ の値が -50 nm であり、入射側および出射側の光軸チルト位相板43, 44の遅相軸チルト方向がそれぞれ液晶セル30の入射側および出射側基板31, 32上における液晶分子配向方向31a, 32aと平行である場合は、光軸チルト位相板43, 44の遅相軸チルト角 θ が約 $30^\circ \sim 70^\circ$ の範囲であれば、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性になる。

【0059】すなわち、図8は、液晶セル30の $\Delta n \cdot d$ の値が 380 nm 、光軸チルト位相板43, 44の $\Delta n' \cdot d'$ の値が -50 nm であり、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位 0° の方向、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位 270° の方向にある液晶表示装置について、光軸チルト位相板43, 44の遅相軸チルト角 θ を変化させて表示の明るさ(Y値)の変化を調べた結果を示しており、ここでは、液晶セル30の電極間に3vの電圧を印加し、液晶表示素子の表示を画面の下縁方向(方位 315° の方向)から見たときの遅相軸チルト角 θ に対する表示の明るさの変化を示している。

【0060】なお、図8において、正の遅相軸チルト角 θ は正方向(入射側光軸チルト位相板43では方位 0° の方向、出射側光軸チルト位相板44では方位 270° の方向)へのチルト角、負の遅相軸チルト角 θ は逆方向(入射側光軸チルト位相板43では方位 180° の方向、出射側光軸チルト位相板44では方位 90° の方向)へのチルト角である。

【0061】この図8のように、上記液晶表示装置は、光軸チルト位相板43, 44の遅相軸チルト角 θ が約 $30^\circ \sim 70^\circ$ の範囲での表示の明るさがほとんど“0”であり、したがって電圧-明るさ特性が“バンプ”のない特性になる。

【0062】また、上記液晶表示装置においては、画面を下縁方向および左右方向から見たときの電圧-明るさ特性が図6および図7に示したような特性であり、視角が 30° より大きいときの表示の明るさが、一旦暗状態になった後、印加電圧が約3.5vより高くなるのにもなって再び僅かながら明るさを増してゆくが、この液晶表示装置では、視角 0° で表示を見たときの明るさがほぼ“0”になる電極間電圧が約3.5vであるため、印加電圧の最高値を3.5v程度に設定すれば、印加電圧の変化に対する明るさの変化が高電圧側において逆になる現象を生じることはない。これは、次の【具体例

2] ~ 【具体例4】の液晶表示装置においても同様である。

【0063】【具体例2】この例は、液晶セル30の $\Delta n \cdot d$ と光軸チルト位相板43, 44の $\Delta n' \cdot d'$ の値を上記【具体例1】と同じ($\Delta n \cdot d = 380\text{ nm}$ 、 $\Delta n' \cdot d' = -50\text{ nm}$)にし、入射側および出射側の光軸チルト位相板43, 44をそれぞれ、その遅相軸チルト方向を液晶セル30の入射側および出射側基板31, 32上の各配向処理方向31a, 32aと直交させて配置した例であり、その場合は、光軸チルト位相板43, 44の遅相軸 Z_n のチルト角 θ を 40° とする。

【0064】図9は、上記液晶表示装置における視角およびその方位と表示のコントラストCRとの関係を示しており、この液晶表示装置では、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位 270° の方向、すなわち液晶セル30の入射側基板31上の配向処理方向31aに対して図上右回りに 90° ずれた方向にあり、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位 0° の方向、すなわち液晶セル30の出射側基板32上の配向処理方向32aに対して図上右回りに 90° ずれた方向にある。

【0065】この図9から分かるように、上記【具体例2】の液晶表示装置は、例えば $CR = 200$ のコントラストが得られる視角が、画面の下縁中央方向(方位 315° の方向)から見たときで約 27° 、下縁中央方向に対して 45° の方向(方位 0° および方位 270° の方向)から見たときで約 28° と十分大きく、従来の液晶表示装置に比べてはるかに広い視野角をもっている。

【0066】また、図10~図12は、上記【具体例2】の液晶表示装置の液晶セル10への電極間印加電圧(V)と表示の明るさ(Y値)との関係を、 0° 、 10° 、 20° 、 30° 、 40° 、 50° の各視角について調べた結果を示す電圧-明るさ特性図であり、図10は表示を 135° の方位から表示を見たときの特性、図11は 315° の方位から見たときの特性、図12は 45° の方位から見たときの特性を示している。なお、 225° の方位から見たときの電圧-明るさ特性は図12とほぼ同じである。

【0067】この図10~図12から分かるように、上記【具体例2】の液晶表示装置は、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性であり、したがって、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

【0068】なお、この例では、光軸チルト位相板43, 44の遅相軸チルト角 θ を 40° としたが、上記のように光軸チルト位相板43, 44の $\Delta n' \cdot d'$ の値が -50 nm であり、入射側および出射側の光軸チルト位相板43, 44の遅相軸チルト方向がそれぞれ液晶セル30の入射側および出射側基板31, 32上における液晶分子配向方向31a, 32aと直交している場合

は、光軸チルト位相板43、44の遅相軸チルト角 θ が約35°～85°の範囲であれば、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性になる。

【0069】図13は、液晶セル30の $\Delta n \cdot d$ の値が380nm、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値が-50nmであり、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位270°の方向、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位0°の方向にある液晶表示装置について、光軸チルト位相板43、44の遅相軸チルト角 θ を変化させて表示の明るさ(Y値)の変化を調べた結果を示しており、ここでは、液晶セル30の電極間に3vの電圧を印加し、液晶表示素子の表示を画面の下縁方向(方位315°の方向)から見たときの遅相軸チルト角 θ に対する表示の明るさの変化を示している。

【0070】なお、図13において、正の遅相軸チルト角 θ は正方向(入射側光軸チルト位相板43では方位270°の方向、出射側光軸チルト位相板44では方位0°の方向)へのチルト角、負の遅相軸チルト角 θ は逆方向(入射側光軸チルト位相板43では方位90°の方向、出射側光軸チルト位相板44では方位180°の方向)へのチルト角である。

【0071】この図13のように、上記液晶表示装置は、光軸チルト位相板43、44の遅相軸チルト角 θ が35°～85°の範囲での表示の明るさがほとんど“0”であり、したがって電圧-明るさ特性が“バンプ”のない特性になる。

【0072】[具体例3]この例は、液晶セル30の $\Delta n \cdot d$ の値を380nm、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値を+50nmとし、入射側および出射側の光軸チルト位相板43、44をそれぞれ、その遅相軸チルト方向を液晶セル30の入射側および出射側基板31、32上の各配向処理方向31a、32aと平行にして配置した例であり、その場合は、光軸チルト位相板43、44の遅相軸 $Z n_e$ のチルト角 θ を70°とする。

【0073】図14は、上記液晶表示装置における視角およびその方位と表示のコントラストCRとの関係を示しており、この液晶表示装置では、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位180°の方向、すなわち液晶セル30の入射側基板31上の配向処理方向31aと逆方向(平行でかつ逆向き)にあり、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位90°の方向、すなわち液晶セル30の出射側基板32上の配向処理方向32aと同方向(平行でかつ同じ向き)にある。

【0074】この図14から分かるように、上記[具体例3]の液晶表示装置は、例えばCR=200のコントラストが得られる視角が、画面の下縁中央方向(方位3

15°の方向)から見たときで約29°、下縁中央方向に対して45°の方向(方位0°および方位270°の方向)から見たときで約21°と十分大きく、従来の液晶表示装置に比べてはるかに広い視野角をもっている。

【0075】また、図15～図17は、上記[具体例3]の液晶表示装置の液晶セル10への電極間印加電圧(V)と表示の明るさ(Y値)との関係を、0°、10°、20°、30°、40°、50°の各視角について調べた結果を示す電圧-明るさ特性図であり、図15は表示を135°の方位から表示を見たときの特性、図16は315°の方位から見たときの特性、図17は45°の方位から見たときの特性を示している。なお、225°の方位から見たときの電圧-明るさ特性は図17とほぼ同じである。

【0076】この図15～図17から分かるように、上記[具体例3]の液晶表示装置は、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性であり、したがって、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

【0077】なお、この例では、光軸チルト位相板43、44の遅相軸チルト角 θ を70°としたが、上記のように光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値が+50nmであり、入射側および出射側の光軸チルト位相板43、44の遅相軸チルト方向がそれぞれ液晶セル30の入射側および出射側基板31、32上における液晶分子配向方向31a、32aと平行である場合は、光軸チルト位相板43、44の遅相軸チルト角 θ が約60°～80°の範囲であれば、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性になる。

【0078】図18は、液晶セル30の $\Delta n \cdot d$ の値が380nm、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値が+50nmであり、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位180°の方向、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位90°の方向にある液晶表示装置について、光軸チルト位相板43、44の遅相軸チルト角 θ を変化させて表示の明るさ(Y値)の変化を調べた結果を示しており、ここでは、液晶セル30の電極間に3vの電圧を印加し、液晶表示素子の表示を画面の下縁方向(方位315°の方向)から見たときの遅相軸チルト角 θ に対する表示の明るさの変化を示している。

【0079】なお、図18において、正の遅相軸チルト角 θ は正方向(入射側光軸チルト位相板43では方位180°の方向、出射側光軸チルト位相板44では方位90°の方向)へのチルト角、負の遅相軸チルト角 θ は逆方向(入射側光軸チルト位相板43では方位0°の方向、出射側光軸チルト位相板44では方位270°の方向)へのチルト角である。

【0080】この図18のように、上記液晶表示装置

は、光軸チルト位相板43、44の遅相軸チルト角 θ が $60^\circ \sim 80^\circ$ の範囲での表示の明るさがほとんど“0”であり、したがって電圧-明るさ特性が“バンプ”のない特性になる。

【0081】〔具体例4〕この例は、液晶セル30の $\Delta n \cdot d$ の値を 380 nm 、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値を $+50 \text{ nm}$ とし、入射側および出射側の光軸チルト位相板43、44をそれぞれ、その遅相軸チルト方向を液晶セル30の入射側および出射側基板31、32上の各配向処理方向31a、32aと直交させて配置した例であり、その場合は、光軸チルト位相板43、44の遅相軸 $Z n_e$ のチルト角 θ を 50° とする。

【0082】図19は、上記液晶表示装置における視角およびその方位と表示のコントラストCRとの関係を示しており、この液晶表示装置では、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位 90° の方向、すなわち液晶セル30の入射側基板31上における液晶分子配向方向31aに対して図上左回りに 90° ずれた方向にあり、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位 180° の方向、すなわち液晶セル30の出射側基板32上における液晶分子配向方向32aに対して図上左回りに 90° ずれた方向にある。

【0083】この図19から分かるように、上記〔具体例4〕の液晶表示装置は、例えば $CR=200$ のコントラストが得られる視角が、画面の下縁中央方向（方位 315° の方向）から見たときで約 25° 、下縁中央方向に対して 45° の方向（方位 0° および方位 270° の方向）から見たときで約 32° と十分大きく、従来の液晶表示装置に比べてはるかに広い視野角をもっている。

【0084】また、図20～図22は、上記〔具体例4〕の液晶表示装置の液晶セル10への電極間印加電圧(V)と表示の明るさ(Y値)との関係を、 0° 、 10° 、 20° 、 30° 、 40° 、 50° の各視角について調べた結果を示す電圧-明るさ特性図であり、図20は表示を 135° の方位から表示を見たときの特性、図21は 315° の方位から見たときの特性、図22は 45° の方位から見たときの特性を示している。なお、 225° の方位から見たときの電圧-明るさ特性は図22とほぼ同じである。

【0085】この図20～図22から分かるように、上記〔具体例4〕の液晶表示装置は、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性であり、したがって、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

【0086】なお、この例では、光軸チルト位相板43、44の遅相軸チルト角 θ を 50° としたが、上記のように光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値が $+50 \text{ nm}$ であり、入射側および出射側の光軸チルト位相板43、44の遅相軸チルト方向がそれぞれ液晶セ

ル30の入射側および出射側基板31、32上の各配向処理方向31a、32aと直交している場合は、光軸チルト位相板43、44の遅相軸チルト角 θ が約 $40^\circ \sim 60^\circ$ の範囲であれば、画面をいずれの方向から見たときの電圧-明るさ特性も“バンプ”のない特性になる。

【0087】図23は、液晶セル30の $\Delta n \cdot d$ の値が 380 nm 、光軸チルト位相板43、44の $\Delta n' \cdot d'$ の値が $+50 \text{ nm}$ であり、入射側光軸チルト位相板43の遅相軸チルト方向43xが方位 90° の方向、出射側光軸チルト位相板44の遅相軸チルト方向44xが方位 180° の方向にある液晶表示装置について、光軸チルト位相板43、44の遅相軸チルト角 θ を変化させて表示の明るさ(Y値)の変化を調べた結果を示しており、ここでは、液晶セル30の電極間に3vの電圧を印加し、液晶表示素子の表示を画面の下縁方向（方位 315° の方向）から見たときの遅相軸チルト角 θ に対する表示の明るさの変化を示している。

【0088】なお、図23において、正の遅相軸チルト角 θ は正方向（入射側光軸チルト位相板43では方位 90° の方向、出射側光軸チルト位相板44では方位 180° の方向）へのチルト角、負の遅相軸チルト角 θ は逆方向（入射側光軸チルト位相板43では方位 270° の方向、出射側光軸チルト位相板44では方位 0° の方向）へのチルト角である。

【0089】この図23のように、上記液晶表示装置は、光軸チルト位相板43、44の遅相軸チルト角 θ が $40^\circ \sim 60^\circ$ の範囲での表示の明るさがほとんど“0”であり、したがって電圧-明るさ特性が“バンプ”のない特性になる。

【0090】このように、上記実施例の液晶表示装置は、TN型の液晶セルを用いたものでありながら、その視野角を広くすることができるとともに、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもないため、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

【0091】なお、上記実施例では、偏光子41を、その透過軸41aを液晶セル30の入射側基板31上の配向処理方向31aとほぼ直交させて配置しているが、この偏光子41の透過軸41aは、液晶セル30の入射側基板31上の配向処理方向31aとほぼ平行であってもよく、その場合でも、上記実施例と同様な効果が得られる。

【0092】また、上記実施例の液晶表示装置は、偏光子41と検光子42の透過軸41a、42aを互いにほぼ直交させたポジ表示タイプのものであるが、本発明の液晶表示装置は、検光子42を、その透過軸42aを偏光子41の透過軸41aとほぼ平行にして配置したネガ表示タイプののものであってもよい。

【0093】さらに、上記実施例では、光軸チルト位相板43、44を、液晶セル30と偏光子41との間と、

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前記液晶セル 30 と検光子 42 との間の両方にそれぞれ設けたが、光軸チルト位相板は、偏光子 41 と検光子 42 との少なくとも一方と液晶セル 30 との間にだけ設けてもよい。

【0094】

【発明の効果】本発明の液晶表示装置は、透明電極と液晶分子の配向方向を規制する配向膜を積層した一対の透明基板間にネマティック液晶を封入しツイスト配列させた液晶セルの入射側に偏光子を配置し、前記液晶セルの出射側に検光子を配置するとともに、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に遅相軸をもちかつこの遅相軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を配置してなり、前記偏光子はその透過軸を前記液晶セルの入射側基板の配向膜に施した配向処理の方向とほぼ直交させるかあるいはほぼ平行にして配置され、前記検光子はその透過軸を前記偏光子の透過軸とほぼ直交させるかあるいはほぼ平行にして配置されているとともに、前記光軸チルト位相板は、その法線に対する遅相軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板の配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されていることを特徴とするものであるから、TN 型の液晶セルを用いたものでありながら、その視野角を広くすることができるとともに、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもなくして、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

【図面の簡単な説明】

【図 1】本発明の一実施例による液晶表示装置の分解斜視図。

【図 2】同液晶表示装置の断面図。

【図 3】光軸チルト位相板の遅相軸と進相軸の方向を示す斜視図

【図 4】〔具体例 1〕の液晶表示装置における視角およびその方位と表示のコントラストとの関係を示す図。

【図 5】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 135° の方位から表示を見たときの電圧-明るさ特性図。

【図 6】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 315° の方位から表示を見たときの電圧-明るさ特性図。

【図 7】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 45° の方位から表示を見たときの電圧-明るさ特性図。

【図 8】同液晶表示装置における光軸チルト位相板の遅相軸チルト角と表示の明るさとの関係を示す図。

【図 9】〔具体例 2〕の液晶表示装置における視角およ

びその方位と表示のコントラストとの関係を示す図。

【図 10】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 135° の方位から表示を見たときの電圧-明るさ特性図。

【図 11】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 315° の方位から表示を見たときの電圧-明るさ特性図。

10 【図 12】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 45° の方位から表示を見たときの電圧-明るさ特性図。

【図 13】同液晶表示装置における光軸チルト位相板の遅相軸チルト角と表示の明るさとの関係を示す図。

【図 14】〔具体例 3〕の液晶表示装置における視角およびその方位と表示のコントラストとの関係を示す図。

20 【図 15】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 135° の方位から表示を見たときの電圧-明るさ特性図。

【図 16】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 315° の方位から表示を見たときの電圧-明るさ特性図。

【図 17】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 45° の方位から表示を見たときの電圧-明るさ特性図。

30 【図 18】同液晶表示装置における光軸チルト位相板の遅相軸チルト角と表示の明るさとの関係を示す図。

【図 19】〔具体例 4〕の液晶表示装置における視角およびその方位と表示のコントラストとの関係を示す図。

【図 20】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 135° の方位から表示を見たときの電圧-明るさ特性図。

40 【図 21】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 315° の方位から表示を見たときの電圧-明るさ特性図。

【図 22】同液晶表示装置における液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 45° の方位から表示を見たときの電圧-明るさ特性図。

【図 23】同液晶表示装置における光軸チルト位相板の遅相軸チルト角と表示の明るさとの関係を示す図。

【図 24】従来の液晶表示装置の分解斜視図。

【図 25】従来の液晶表示装置の断面図。

50 【図 26】従来の液晶表示装置における視角およびその

方位と表示のコントラストとの関係を示す図。

【図 27】従来の液晶表示装置の液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 135° の方位から表示を見たときの電圧-明るさ特性図。

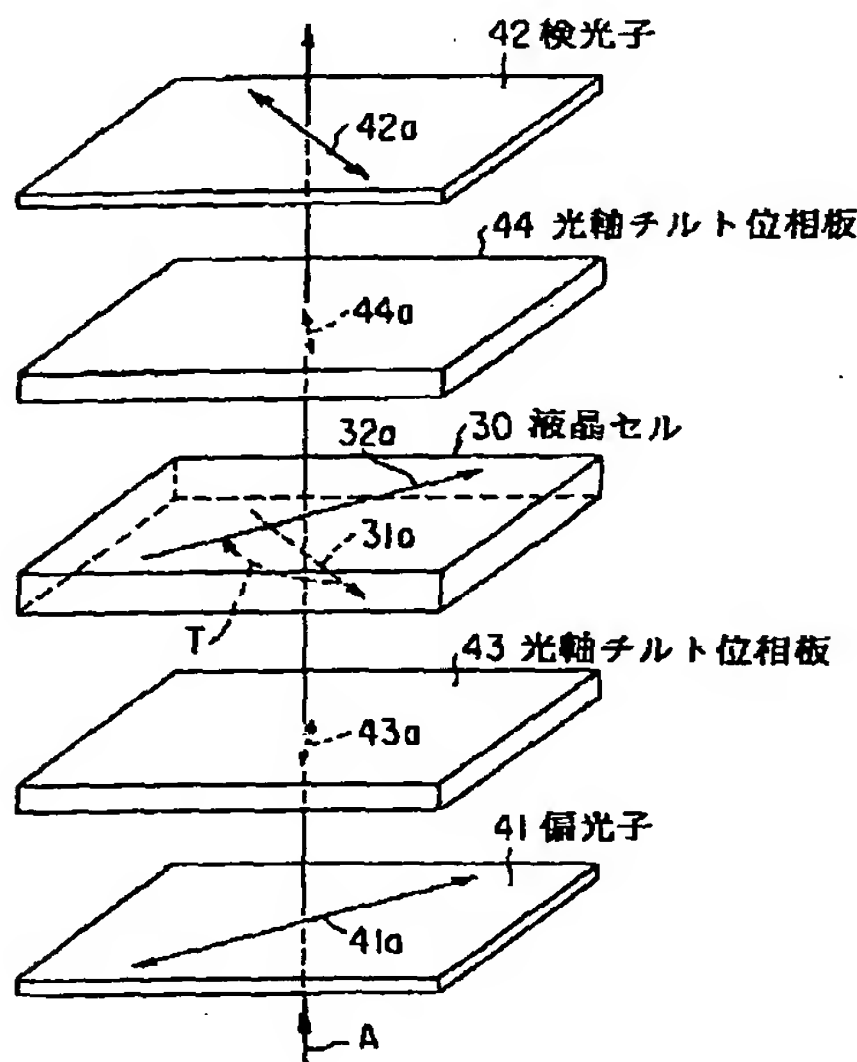
【図 28】従来の液晶表示装置の液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 315° の方位から表示を見たときの電圧-明るさ特性図。

【図 29】従来の液晶表示装置の液晶セルへの電極間印加電圧と表示の明るさとの関係を各視角について調べた結果を示す 45° の方位から表示を見たときの電圧-明るさ特性図。

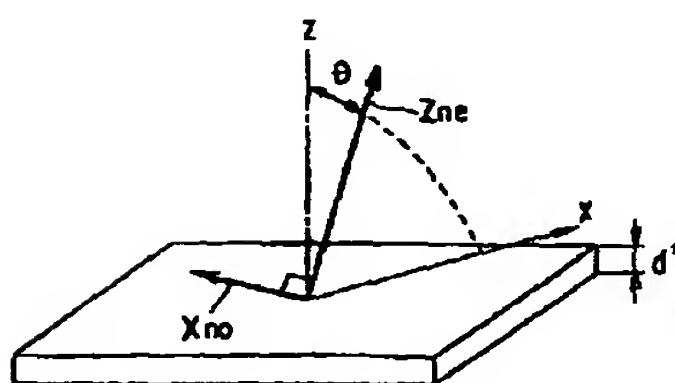
【符号の説明】

30…TN型液晶セル

【図 1】



【図 3】



31…入射側基板

32…出射側基板

33, 34…透明電極

35, 36…配向膜

38…液晶

31a…液晶セルの入射側基板上の配向処理方向

32a…液晶セルの出射側基板上の配向処理方向

T…液晶セルの液晶分子ツイスト方向

41…偏光子

41a…透過軸

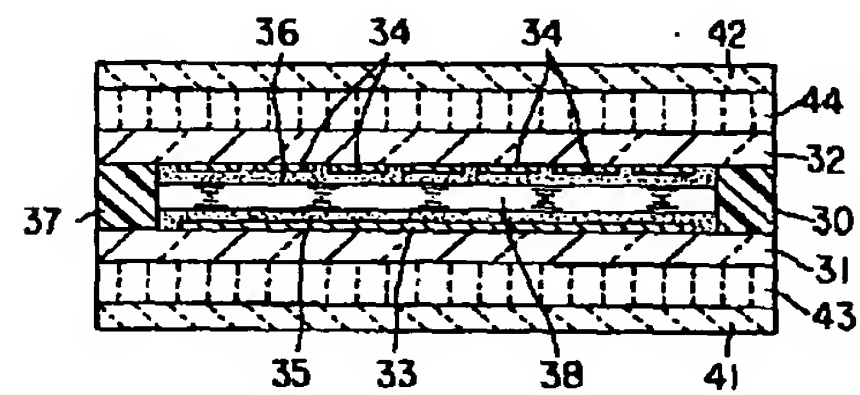
42…検光子

42a…透過軸

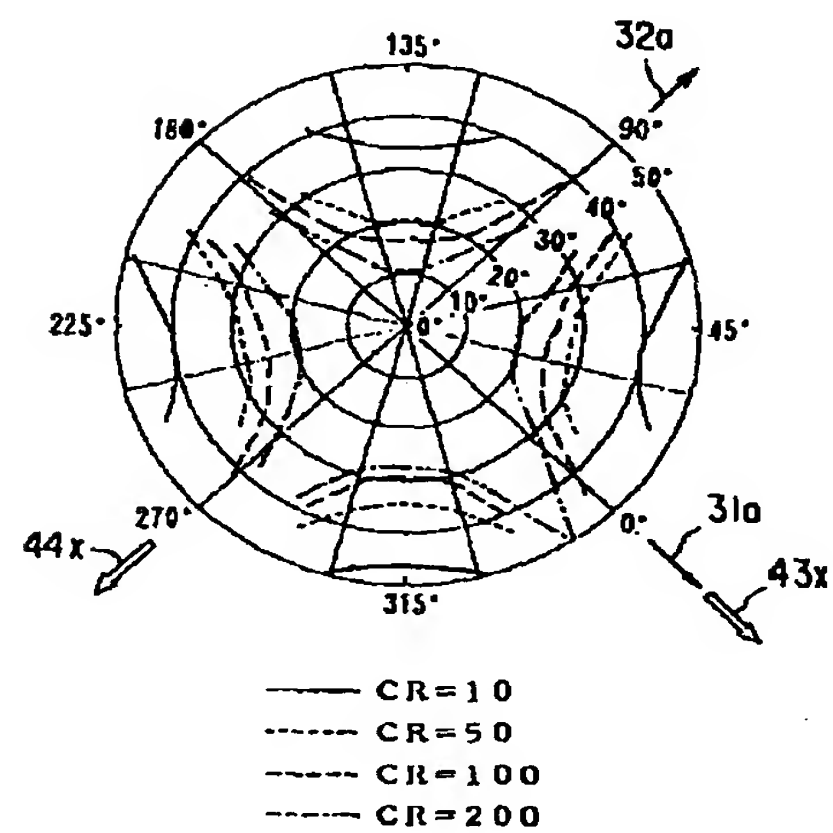
43, 44…光軸チルト位相板

43a, 44a…遅相軸

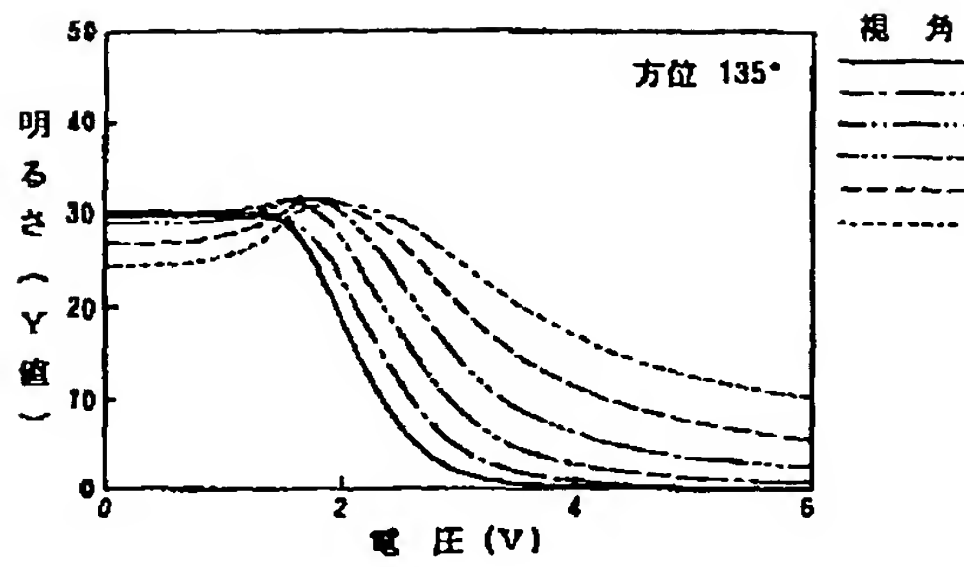
【図 2】



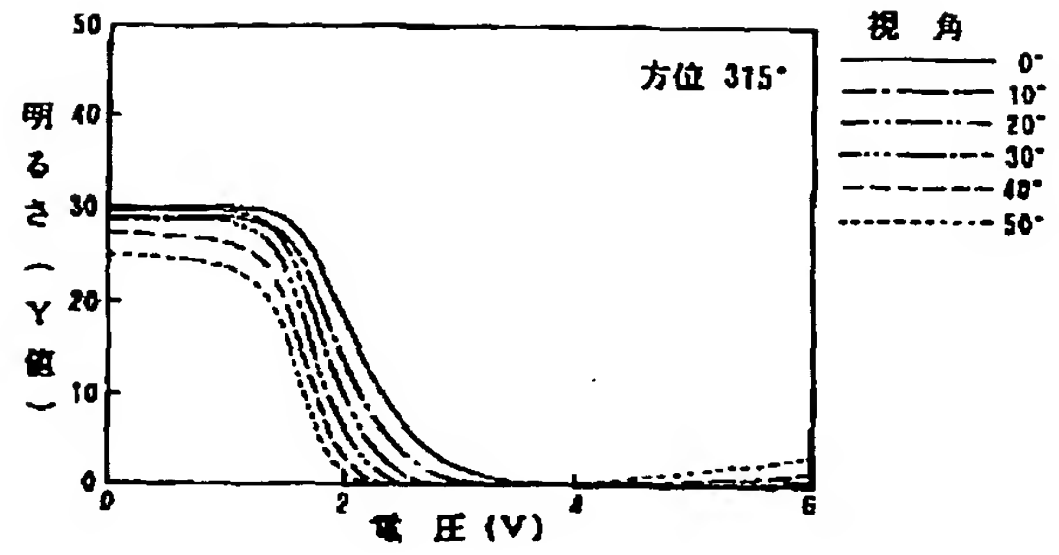
【図 4】



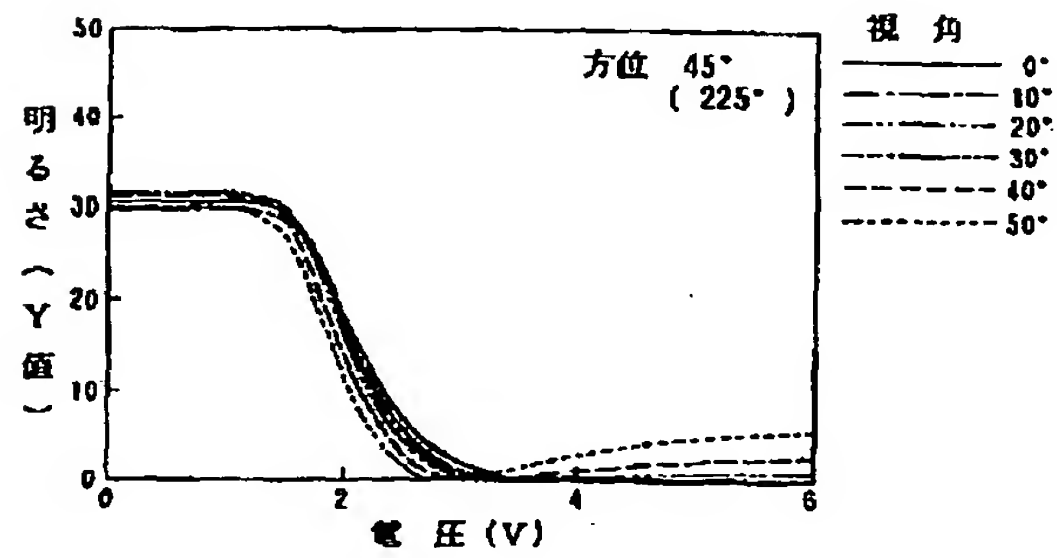
【図5】



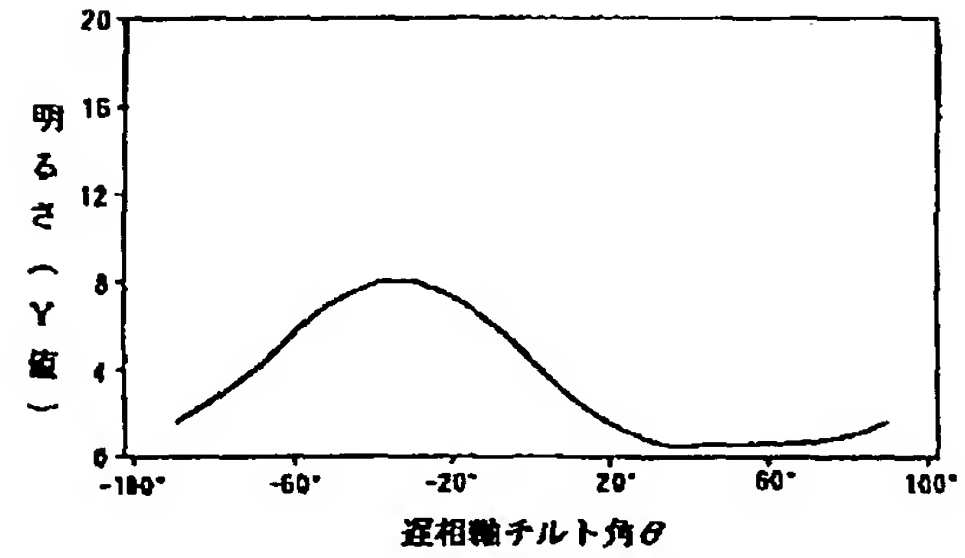
【図6】



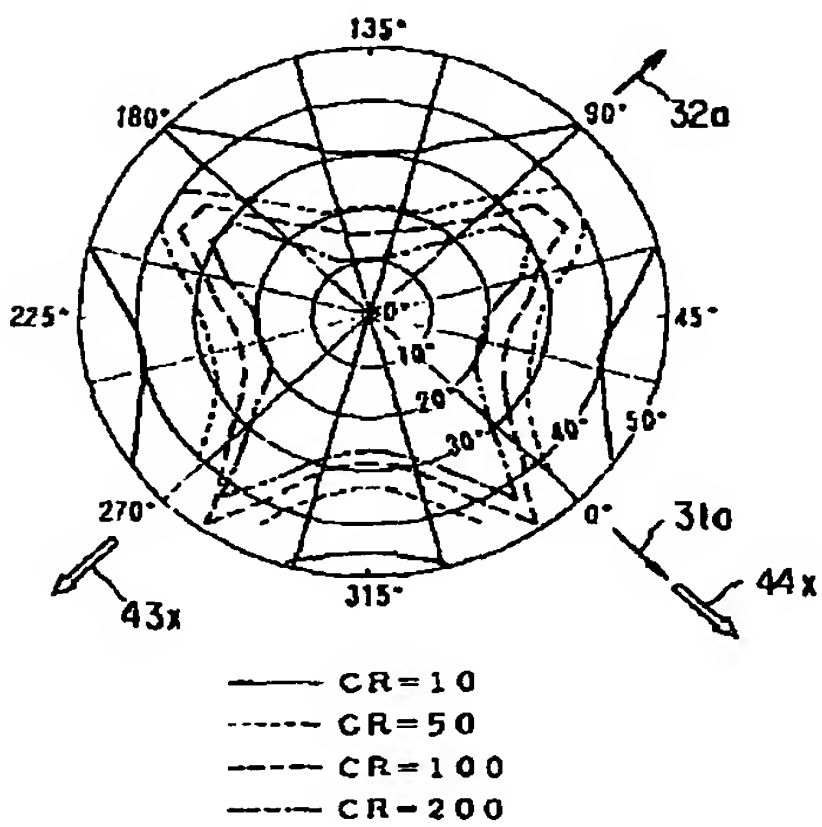
【図7】



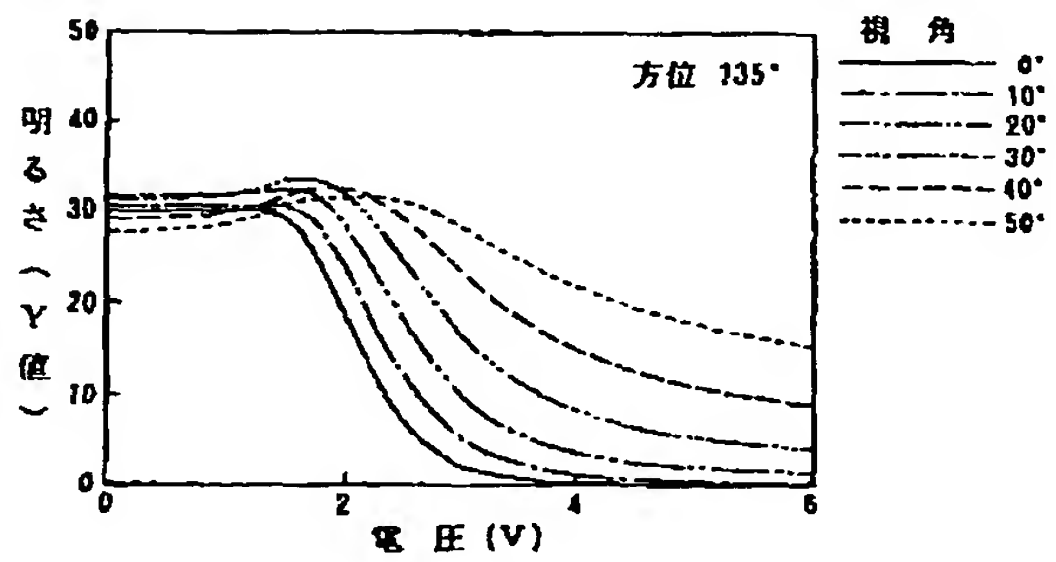
【図8】



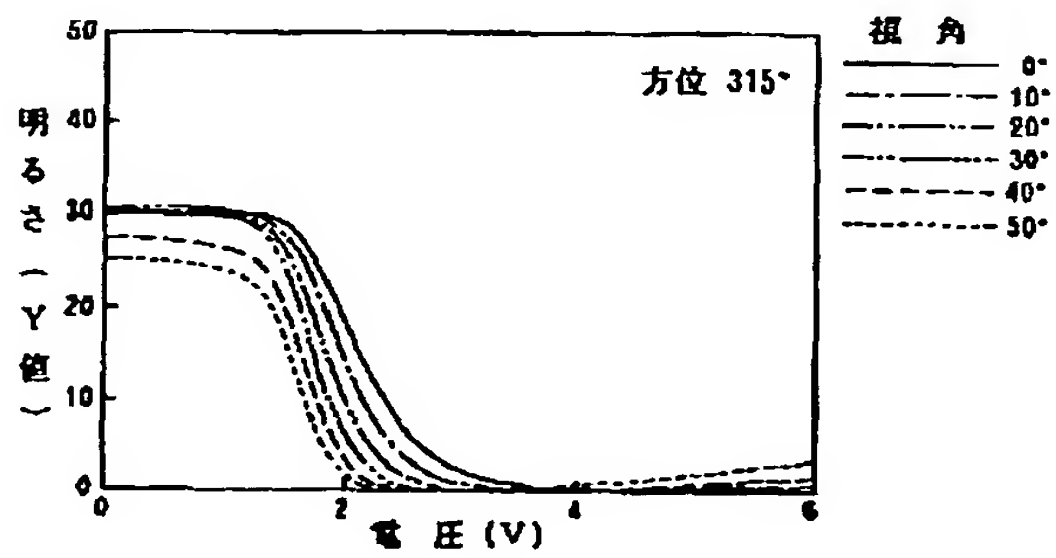
【図9】



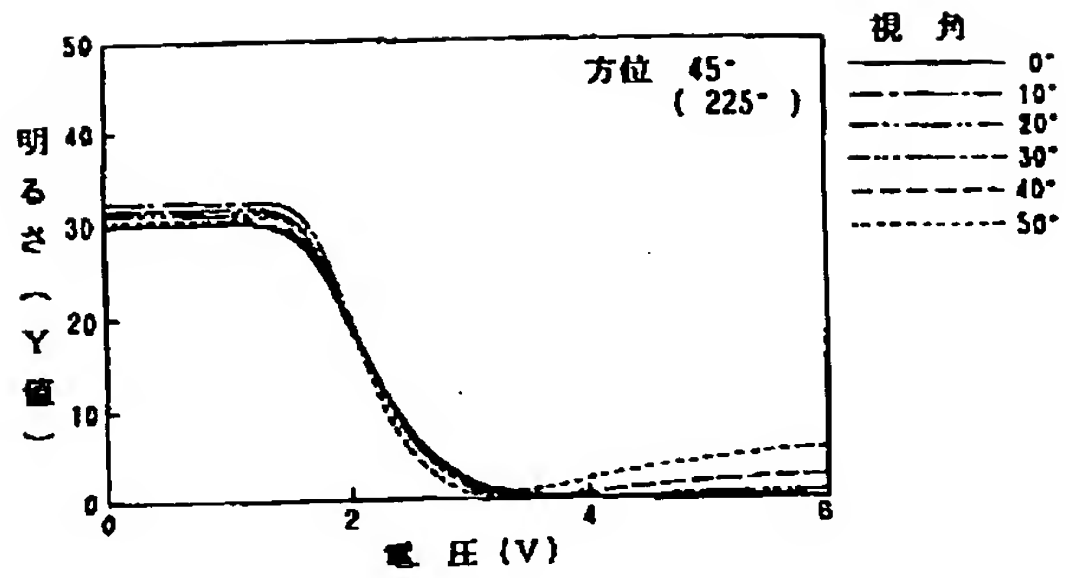
【図10】



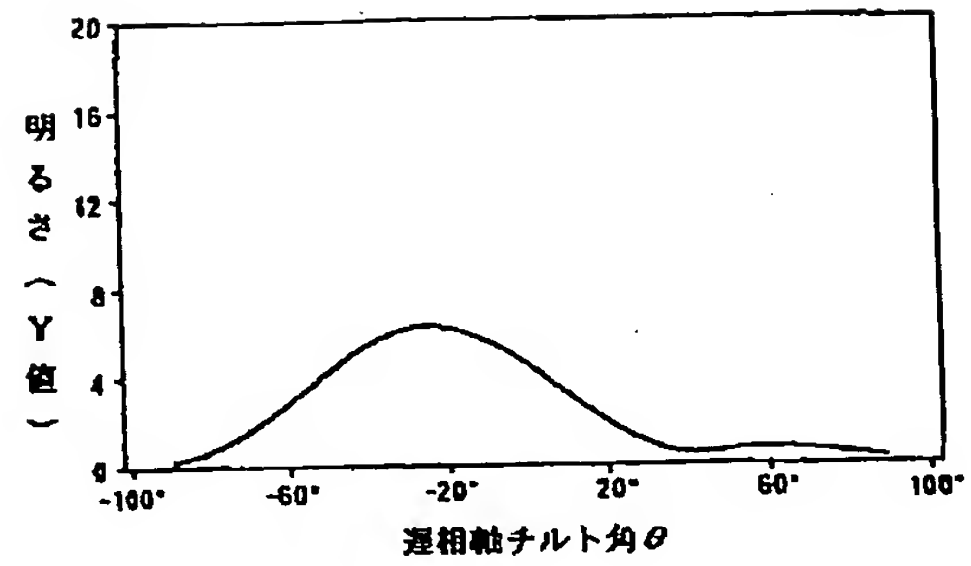
【図11】



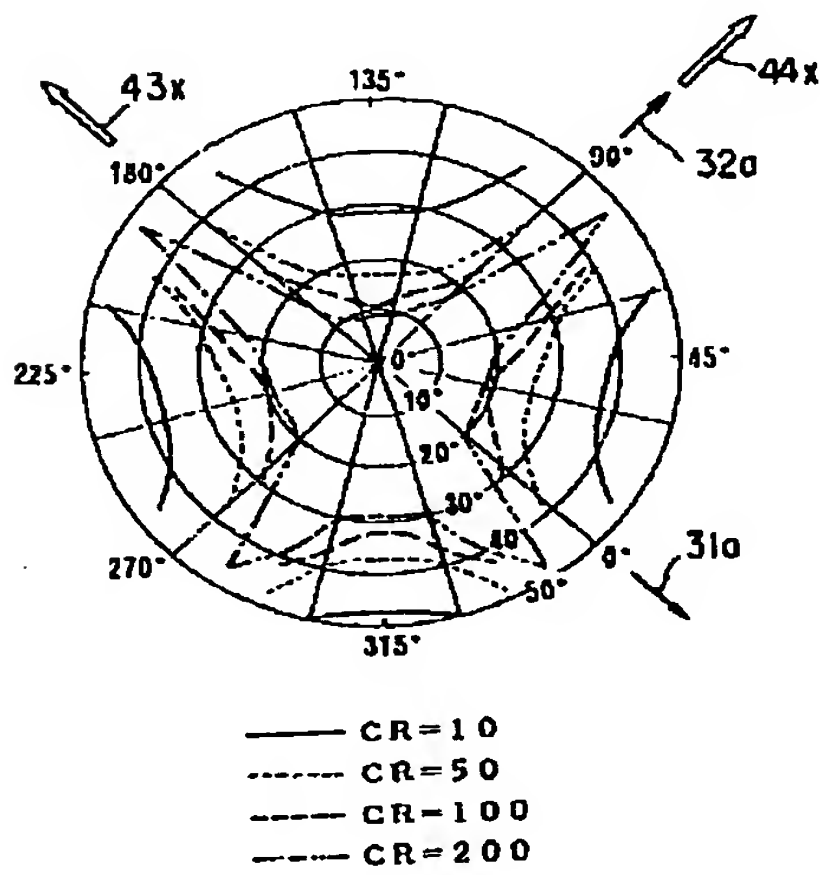
【図12】



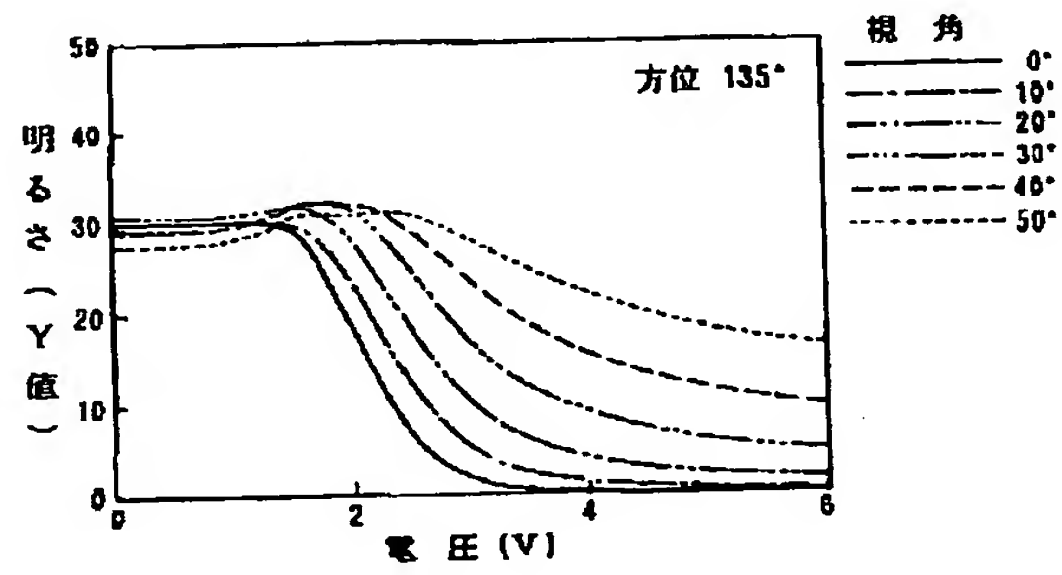
【図13】



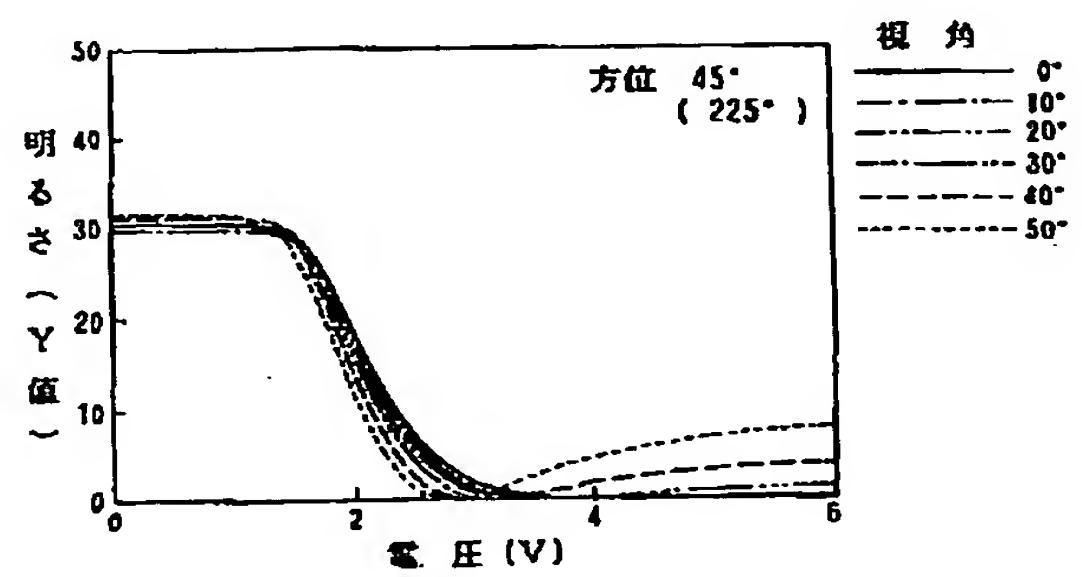
【図14】



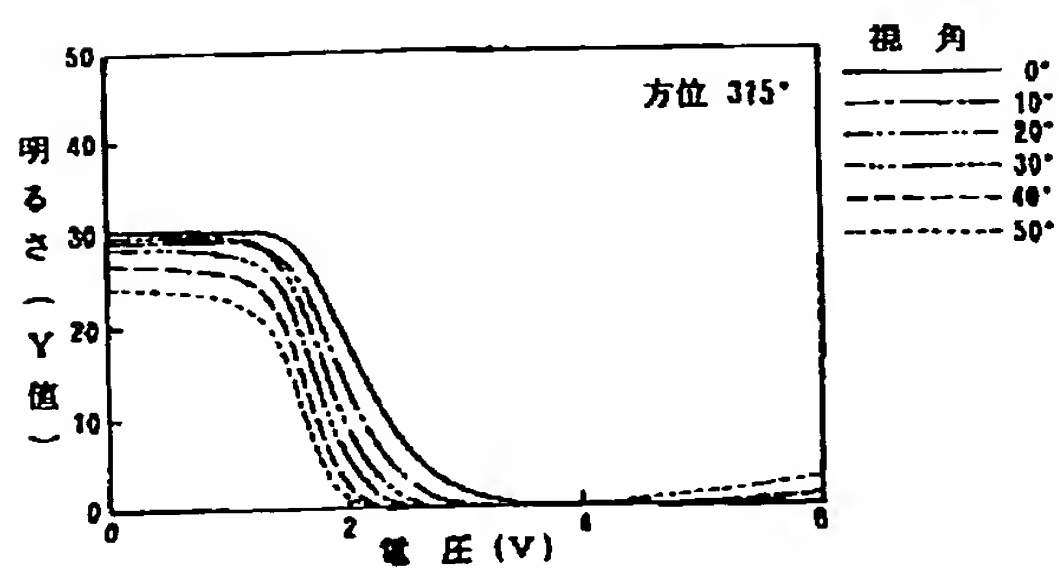
【図15】



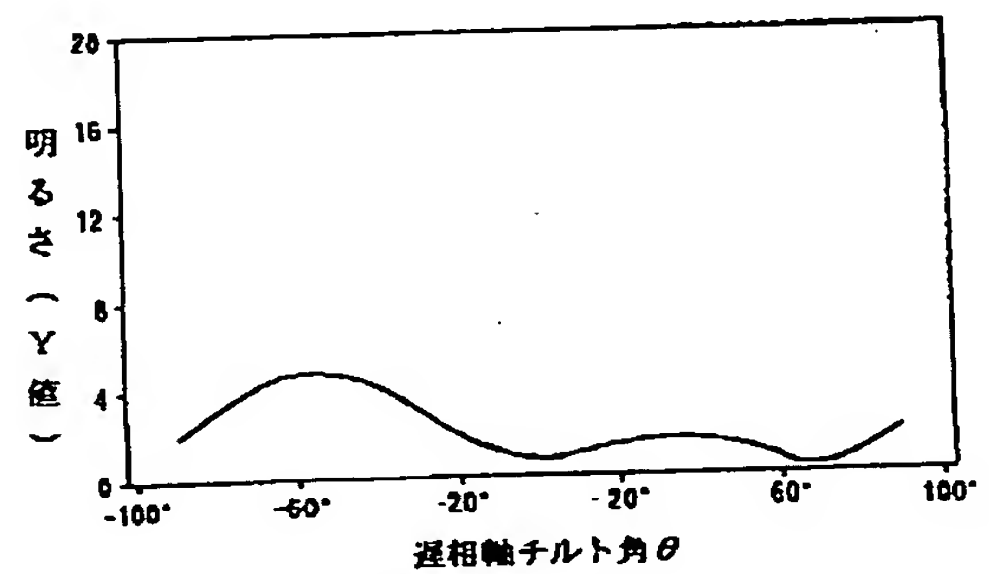
【図17】



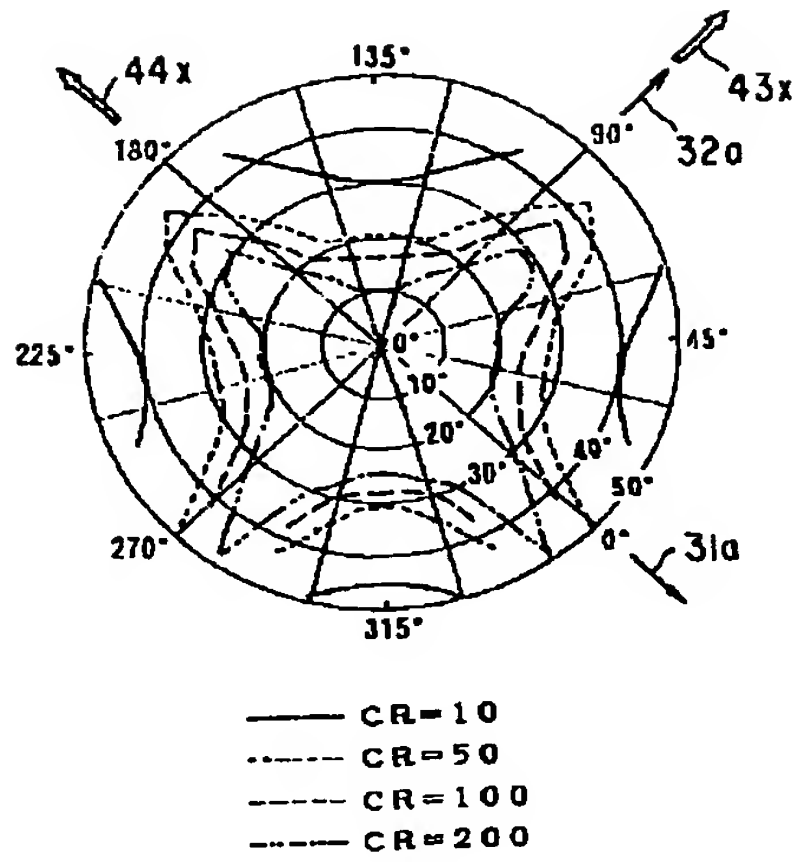
【図16】



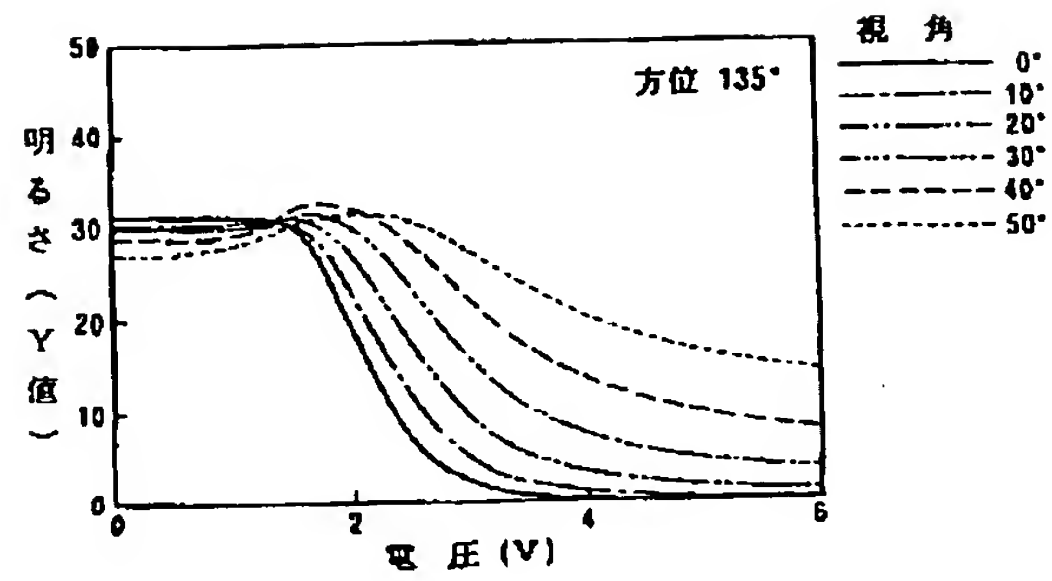
【図18】



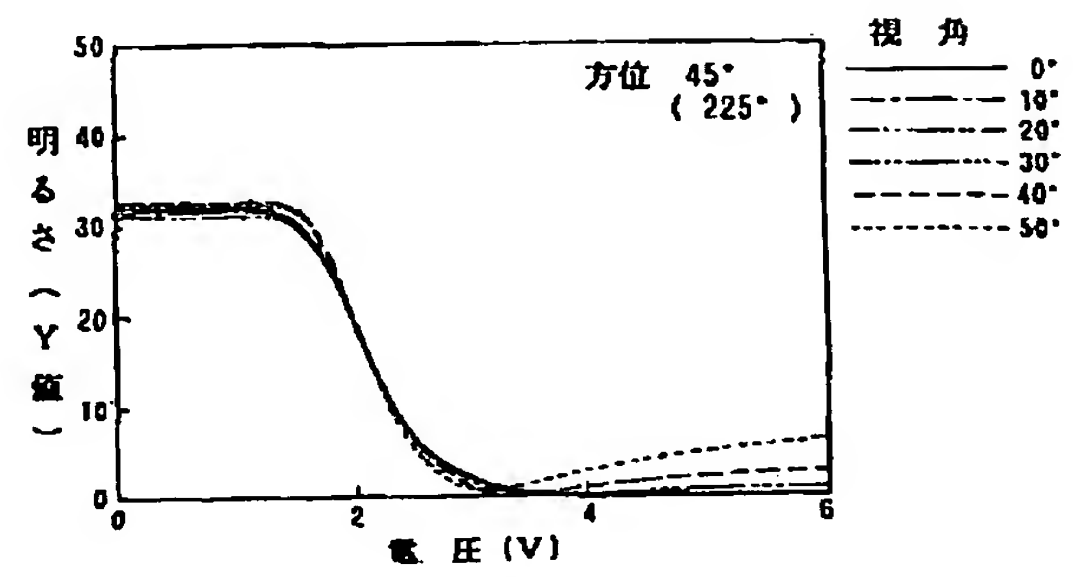
【図19】



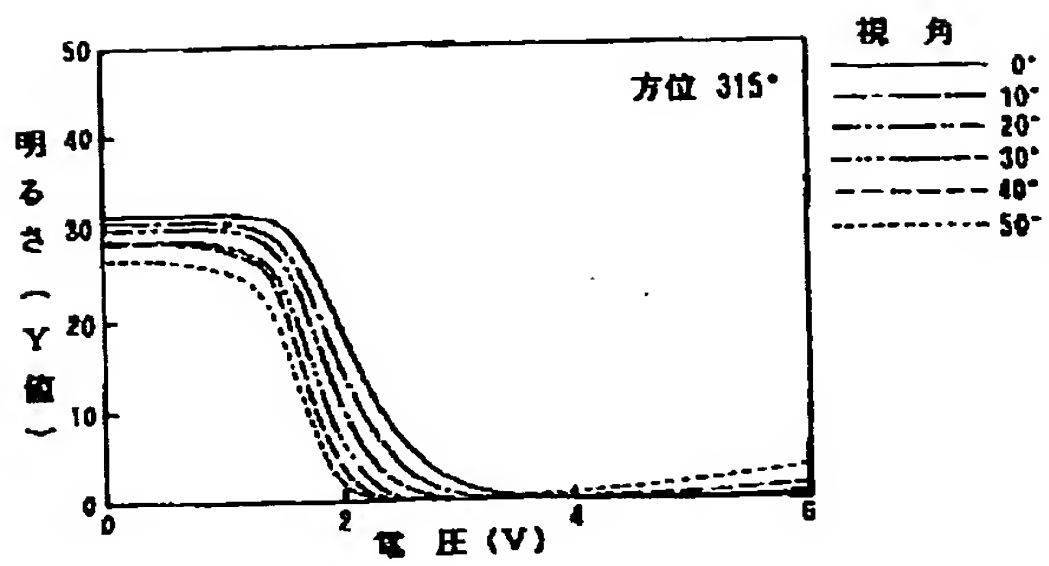
【図20】



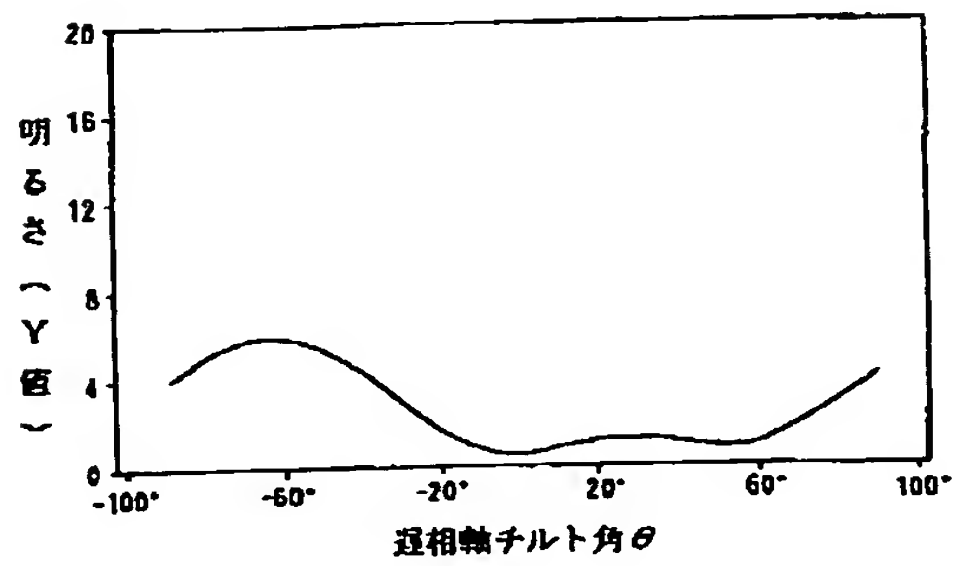
【図22】



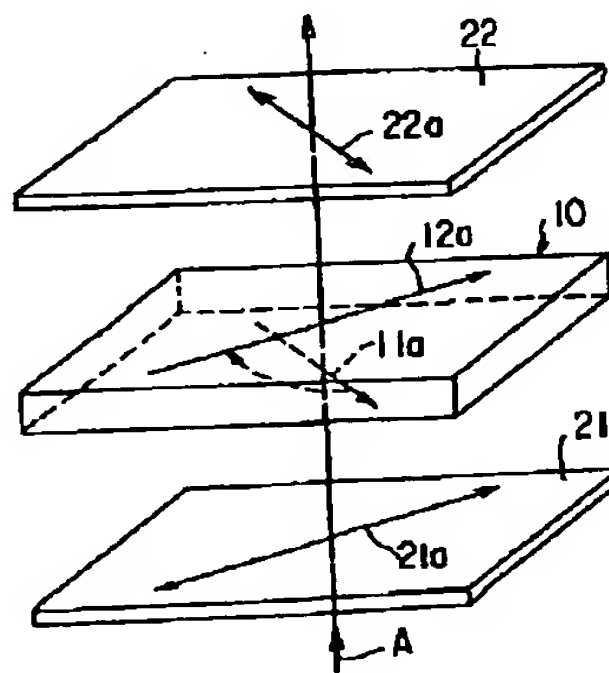
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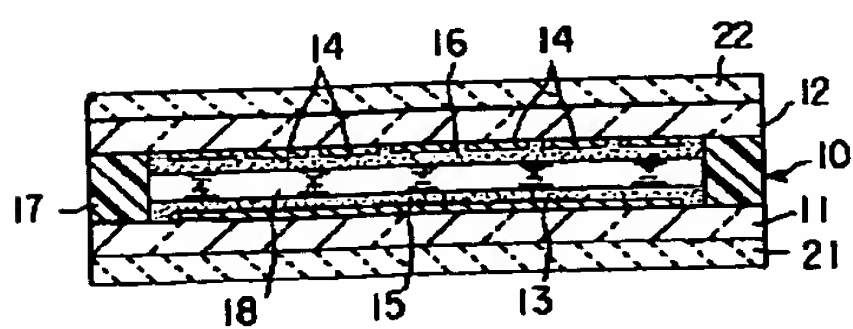
【図23】



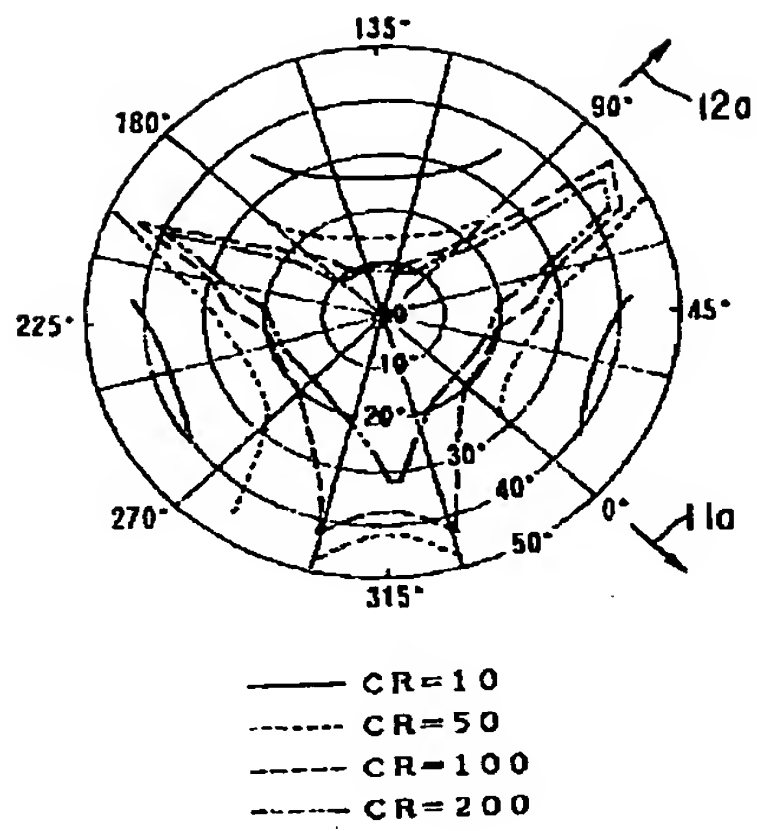
【図24】



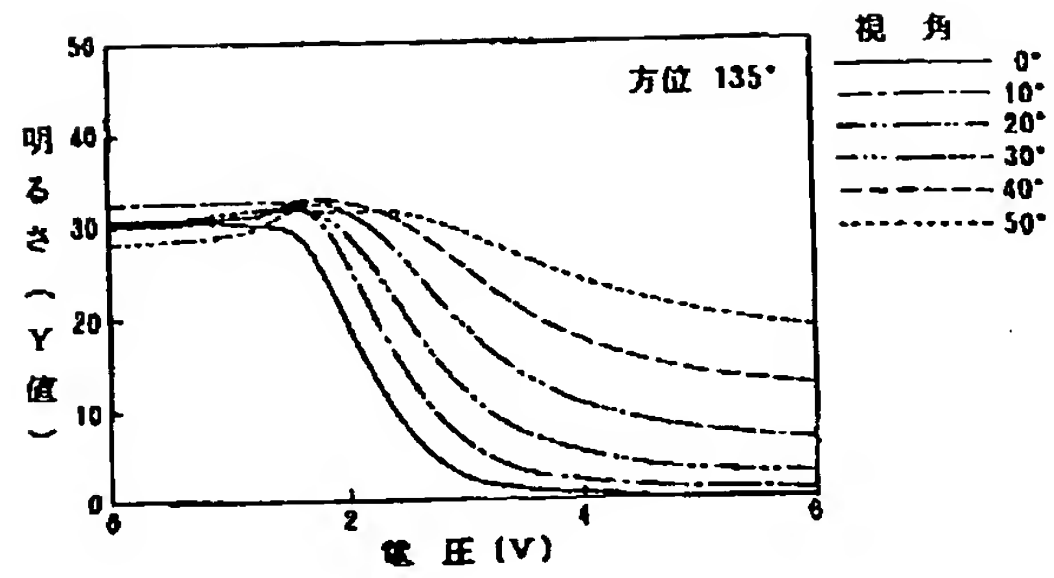
【図25】



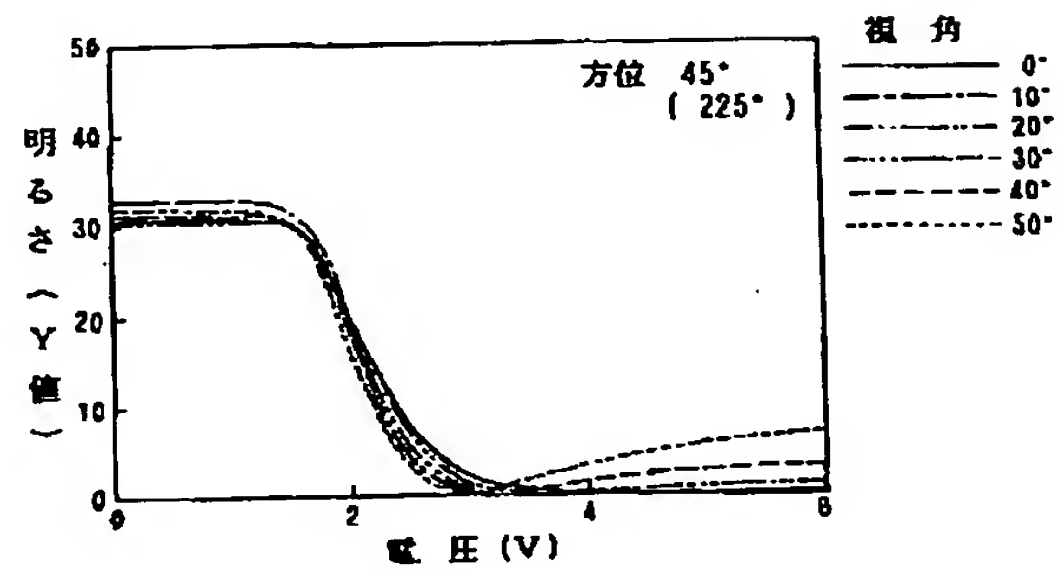
【図26】



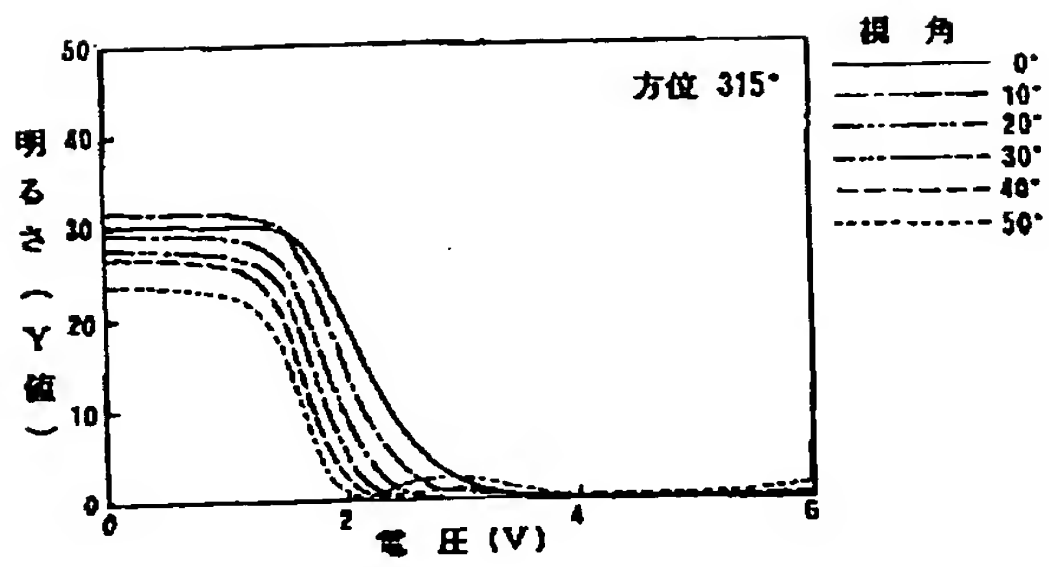
【図27】



【図29】



【図28】



【公報種別】特許法第 17 条の 2 の規定による補正の掲載
【部門区分】第 6 部門第 2 区分
【発行日】平成 13 年 8 月 31 日 (2001. 8. 31)

【公開番号】特開平 7-128658
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【出願番号】特願平 5-274249
【国際特許分類第 7 版】
G02F 1/1335 510
G02B 5/30
【FI】
G02F 1/1335 510
G02B 5/30

【手続補正書】

【提出日】平成 12 年 11 月 1 日 (2000. 11. 1)

【手続補正 1】

【補正対象書類名】明細書

【補正対象項目名】特許請求の範囲

【補正方法】変更

【補正内容】

【特許請求の範囲】

【請求項 1】透明電極と液晶分子の配向方向を規制する配向膜を積層した一対の透明基板間にネマティック液晶を封入しツイスト配列させた液晶セルの入射側に偏光子を配置し、前記液晶セルの出射側に検光子を配置するとともに、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に光軸をもちかつこの光軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を配置してなり、前記偏光子はその透過軸を前記液晶セルの入射側基板上の配向膜に施した配向処理の方向とほぼ直交させるかあるいはほぼ平行にして配置され、前記検光子はその透過軸を前記偏光子の透過軸とほぼ直交させるかあるいはほぼ平行にして配置されているとともに、前記光軸チルト位相板は、その法線に対する光軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板上の配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されていることを特徴とする液晶表示装置。

【請求項 2】光軸チルト位相板は、液晶セルと偏光子との間と、前記液晶セルと検光子との間の両方にそれぞれ設けられており、この両光軸チルト位相板は、その法線に対する光軸のチルト方向を互いにほぼ直交させて配置されていることを特徴とする請求項 1 に記載の液晶表示装置。

【手続補正 2】

【補正対象書類名】明細書

【補正対象項目名】0025

【補正方法】変更

【補正内容】

【0025】

【課題を解決するための手段】本発明の液晶表示装置は、透明電極と液晶分子の配向方向を規制する配向膜を積層した一対の透明基板間にネマティック液晶を封入しツイスト配列させた液晶セルの入射側に偏光子を配置し、前記液晶セルの出射側に検光子を配置するとともに、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に光軸をもちかつこの光軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を配置してなり、前記偏光子はその透過軸を前記液晶セルの入射側基板上の配向膜に施した配向処理の方向とほぼ直交させるかあるいはほぼ平行にして配置され、前記検光子はその透過軸を前記偏光子の透過軸とほぼ直交させるかあるいはほぼ平行にして配置されているとともに、前記光軸チルト位相板は、その法線に対する光軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板上の配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されていることを特徴とするものである。

【手続補正 3】

【補正対象書類名】明細書

【補正対象項目名】0026

【補正方法】変更

【補正内容】

【0026】本発明の一実施態様としては、光軸チルト位相板を、液晶セルと偏光子の間と、前記液晶セルと検光子との間の両方にそれぞれ設け、この両光軸チルト位相板を、その法線に対する光軸のチルト方向を互いにほぼ直交させて配置することが考えられる。

【手続補正 4】

【補正対象書類名】明細書

【補正対象項目名】 0041

【補正方法】 変更

【補正内容】

【0041】 この光軸チルト位相板43, 44は、遅相軸 Zn_e 方向における光の屈折率 n_e と、進相軸 Xn_o 方向における光の屈折率 n_o とによって決まる屈折率異方性 $\Delta n'$ ($\Delta n' = n_e - n_o$) をもっており、この光軸チルト位相板43, 44の屈折率異方性 $\Delta n'$ と位相板厚さ d' との積 $\Delta n' \cdot d'$ の値は、 $-300 \sim 300 \text{ nm}$ である。なお、この実施例では、光軸チルト位相板43, 44の進相軸 Xn_o 方向における屈折率 n_o を1.581とし、遅相軸 Zn_e 方向における屈折率 n_e を調整して所望の $\Delta n' \cdot d'$ を得ている。

【手続補正5】

【補正対象書類名】 明細書

【補正対象項目名】 0094

【補正方法】 変更

【補正内容】

【0094】

【発明の効果】 本発明の液晶表示装置は、透明電極と液晶分子の配向方向を規制する配向膜を積層した一対の透

明基板間にネマティック液晶を封入しツイスト配列させた液晶セルの入射側に偏光子を配置し、前記液晶セルの出射側に検光子を配置するとともに、前記偏光子と検光子との少なくとも一方と前記液晶セルとの間に、厚さ方向に光軸をもちかつこの光軸が法線に対し所定角度斜めにチルトした光軸チルト位相板を配置してなり、前記偏光子はその透過軸を前記液晶セルの入射側基板上の配向膜に施した配向処理の方向とほぼ直交させるかあるいはほぼ平行にして配置され、前記検光子はその透過軸を前記偏光子の透過軸とほぼ直交させるかあるいはほぼ平行にして配置されているとともに、前記光軸チルト位相板は、その法線に対する光軸のチルト方向を、前記液晶セルの前記光軸チルト位相板が隣接する基板上の配向処理方向とほぼ直交させるかあるいはほぼ平行にして配置されていることを特徴とするものであるから、TN型の液晶セルを用いたものでありながら、その視野角を広くすることができるとともに、画面を見る方向および視角によって電圧-明るさ特性に“バンプ”が生じることもなくして、“ちらつき”や階調の反転のない高品質の表示を得ることができる。

PATENT ABSTRACTS OF JAPAN

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 (43)Date of publication of application : 19.05.1995

(51)Int.Cl.

G02F 1/1335
 G02B 5/30

(21)Application number : 05-274249
 (22)Date of filing : 02.11.1993

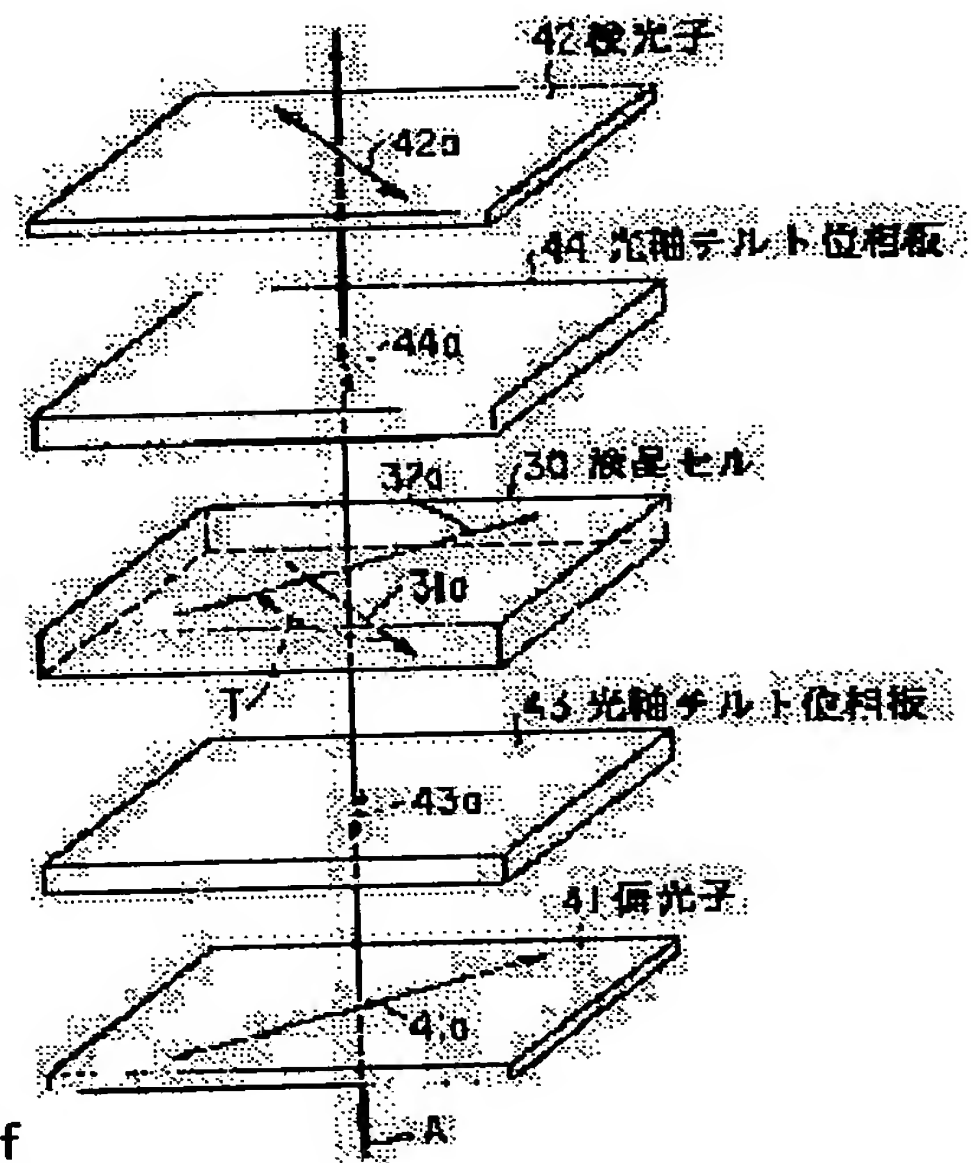
(71)Applicant : CASIO COMPUT CO LTD
 (72)Inventor : MIYAZAWA YOSHINAGA

(54) LIQUID CRYSTAL DISPLAY DEVICE

(57)Abstract:

PURPOSE: To provide high-quality display free from 'flickering' and gradation inversion by widening the visual field angle of the liquid crystal display device for which a liquid crystal cell of a TN type is used and obviating the generation of 'bumps' in voltage-brightness characteristics by direction of viewing a screen and visual angles.

CONSTITUTION: Optical axis tilt phase plates 43, 44 which respectively have delay phase axes 43a, 44a in their thickness direction and tilting these delay axes diagonally at a prescribed angle with the normal are arranged between the TN type liquid crystal cell 30 and a polarizer and between the liquid crystal cell 30 and an analyzer 42. The tilt direction of the delay axis of the incident side optical axis tilt phase plate 43 with the normal is intersected nearly orthogonally with the orientation treatment direction 31a of the liquid crystal cell 30 on an incident side substrate. The tilt direction of the delay axis of the exit side optical axis tilt phase plate 44 with the normal is intersected nearly orthogonally with the orientation treatment direction 32a of the liquid crystal cell 30 on an exit side substrate.



LEGAL STATUS

[Date of request for examination] 01.11.2000

[Date of sending the examiner's decision of rejection] 14.01.2003

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's
decision of rejection]

[Date of extinction of right]

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2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] While arranging a polarizer to the incidence side of the liquid crystal cell which the pneumatic liquid crystal was enclosed [liquid crystal cell] and carried out the twist array between the transparent substrates of the couple which carried out the laminating of the orientation film which regulates the direction of orientation of a liquid crystal molecule to the transparent electrode and arranging an analyzer to the outgoing radiation side of the aforementioned liquid crystal cell It comes to arrange the optical-axis tilt phase plate in which had a lagging axis in the thickness direction and the lagging axis of a parenthesis carried out the tilt aslant [predetermined angle] to the normal between at least one side of the aforementioned polarizer and an analyzer, and the aforementioned liquid crystal cell. Make the direction of the orientation processing which gave the transparency shaft to the orientation film on the incidence side substrate of the aforementioned liquid crystal cell, and the aforementioned polarizer cross at right angles mostly, or make it parallel mostly and it is arranged. While the aforementioned analyzer's making the transparency shaft of the aforementioned polarizer, and the transparency shaft cross at right angles mostly, or making it parallel mostly and arranging it, the aforementioned optical-axis tilt phase plate The liquid crystal display characterized by making the orientation processing direction on the substrate which the aforementioned optical-axis tilt phase plate of the aforementioned liquid crystal cell adjoins, and the direction of a tilt of the lagging axis to the normal cross at right angles mostly, or making it parallel mostly and being arranged.

[Claim 2] An optical-axis tilt phase plate is a liquid crystal display according to claim 1 characterized by being prepared in both between the aforementioned liquid crystal cell and an analyzer between a liquid crystal cell and polarizers, respectively, and for both this opticals-axis tilt phase plate making the direction of a tilt of the lagging axis to the normal intersect perpendicularly mostly mutually, and being arranged.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the liquid crystal display using the TN type liquid crystal cell.

[0002]

[Description of the Prior Art] Generally the thing using the TN (Twisted Nematic) type liquid crystal cell as a liquid crystal display is used. Drawing 24 and drawing 25 are the conventional decomposition perspective diagrams and cross sections of a liquid crystal display, and this liquid crystal display element consists of a TN liquid crystal cell 10, a polarizer 21 arranged at the incidence side of the light A to this liquid crystal cell 10, and an analyzer 22 arranged at the outgoing radiation side of the aforementioned liquid crystal cell 10.

[0003] The above-mentioned liquid crystal cell 10 joins the transparent substrates 11 and 12 of a couple which consist of glass etc. through the frame-like sealant 17 in the periphery section, as shown in drawing 25. It is what enclosed liquid crystal 18 with both this substrate 11 and the field surrounded by the sealant 17 between 12. The transparent electrodes 13 and 14 for impressing electric field to a liquid crystal layer, respectively are formed in the field where both the substrates 11 and 12 counter mutually, and the orientation films 15 and 16 which regulate the direction of orientation of a liquid crystal molecule are formed on it.

[0004] And with these orientation films 15 and 16, about 90 degrees of the orientation regulation directions to the liquid crystal molecule by the above-mentioned orientation films 15 and 16 are shifted mutually, and where it has a certain pre tilt angle to the film surface, on the other hand, orientation of the liquid crystal molecule is carried out to **, and it is carrying out the twist array on about 90-degree twist square between both the substrates 11 and 12.

[0005] That is, it sets to drawing 24, in the direction of liquid crystal molecular orientation on (the 15th page of orientation film) the incidence side substrate 11 of a liquid crystal cell 10, and 12a, the direction of liquid crystal molecular orientation on (the 16th page of orientation film) the outgoing radiation side substrate 12 and T show [11a] the twist direction of a liquid crystal molecule, and the liquid crystal molecule is carrying out the twist array on about 90-degree twist square in the clockwise direction toward the outgoing radiation side substrate 12 from the incidence side substrate 11. In addition, generally as the above-mentioned liquid crystal cell 10, that whose value of product $\Delta n \cdot d$ of refractive-index anisotropy Δn of liquid crystal 18 and the liquid crystal thickness d is 350-450nm is used.

[0006] On the other hand, in 21a, the transparency shaft of a polarizer 21 and 22a show the transparency shaft of the above-mentioned analyzer 22 in drawing 24. a polarizer 21 Direction of liquid crystal molecular orientation 11a on the incidence side substrate 11 of a liquid crystal cell 10 and the transparency shaft 21a are made to cross at right angles mostly, or it is mostly made parallel and is arranged. an analyzer 22 Transparency shaft 21a of the aforementioned polarizer 21 and the transparency shaft 22a are made to cross at right angles mostly, or it is mostly made parallel and is

arranged.

[0007] In addition, the transparency shafts 21a and 22a were made for a polarizer 21 and an analyzer 22 to intersect perpendicularly mostly mutually like [a thing a positive display type thing and negative display type is shown in the liquid crystal display using a TN liquid crystal cell, and / in a positive display type liquid crystal display] drawing 24 , it has arranged, the transparency shafts 21a and 22a of each other were mostly made parallel for the polarizer 21 and the analyzer 22 in the negative display type liquid crystal display, and it arranges.

[0008] The above-mentioned liquid crystal displays are the electrode 13 of a liquid crystal cell 10, and the thing by which a display drive is carried out by impressing voltage among 14 by impressing electric field to the inter-electrode liquid crystal layer. When OFF voltage is impressed between an electrode 13 and 14 (i.e., when the array state of a liquid crystal molecule is in an early twist array state), the linearly polarized light which carried out incidence to the liquid crystal cell 10 through the polarizer 21 is **** (ed) about 90 degrees, and carries out incidence of the polarization direction to an analyzer 22.

[0009] Moreover, start a liquid crystal molecule maintaining a twist array state from an early twist array state, if ON voltage is impressed between the electrode 13 of a liquid crystal cell 10, and 14, and a **** operation in a liquid crystal layer becomes small. If a liquid crystal molecule starts in the erection state mostly and arranges, a **** operation in a liquid crystal layer is almost set to 0, and while the linearly polarized light which carried out incidence through the polarizer 21 has been in the polarization state, incidence will be carried out to an analyzer 22 through a liquid crystal cell.

[0010] For this reason, in the liquid crystal display of the positive display type which is making the transparency shafts 21a and 22a intersect perpendicularly mostly mutually of a polarizer 21 and an analyzer 22 Most light which passed along this portion when OFF voltage was impressed between the electrode 13 of a liquid crystal cell 10 and 14 penetrates an analyzer 22, and a display will be in the Ming state, and if ON voltage which a liquid crystal molecule starts in the erection state mostly, and is arranged is impressed Most light which passed along this portion is absorbed with an analyzer 22, and a display will be in a dark state.

[0011] Moreover, if ON voltage in which a liquid crystal molecule changes orientation into the middle state of an early twist array state and an erection array state is impressed, a part of light which passed along this portion is absorbed with an analyzer 22, other light will penetrate an analyzer 22 and the luminosity of a display will become the middle gradation of the Ming state and a dark state.

[0012] In addition, the thing using the liquid crystal cell of the segment method which formed in the above-mentioned liquid crystal display the common electrode which forms the segment electrode of the configuration corresponding to a display pattern in one substrate, and counters the substrate of another side with the aforementioned segment electrode, The thing using the liquid crystal cell of the simple matrix method which formed two or more scanning electrodes of each other in one substrate in parallel, and the aforementioned scanning electrode and the substrate of another side were made to cross at right angles, and formed two or more signal electrodes, There is a thing using the liquid crystal cell of the active matrix method which carried out array formation of two or more pixel electrodes and its active elements (for example, TFT etc.) in the line writing direction and the direction of a train, and formed the counterelectrode in one substrate at the substrate of another side.

[0013]

[Problem(s) to be Solved by the Invention] By the way, the liquid crystal display using the above-mentioned TN liquid crystal cell has the very bright display of the Ming state, and since the display of a dark state is a display near the "black" which does not almost have a light leak, the high display of contrast (light-and-darkness ratio) is obtained, but on the other hand the viewing-angle range (henceforth an angle of visibility) which can see a display by good contrast has the problem of being narrow.

[0014] When transparency shaft 21 of both substrates [of a liquid crystal cell 10] 11, direction [on 12] a [11] and 12a of liquid crystal molecular orientation, and polarizer 21 a and transparency shaft 22a of an analyzer 22 explained the angle of visibility of the conventional liquid crystal display about the liquid crystal display which tended to be shown in drawing 24 , the relation with the contrast CR of the viewing angle (angle to a line perpendicular to a screen) in this liquid crystal display and its direction,

and a display came to be shown in drawing 26 . In addition, the value of $\Delta n \cdot d$ of the liquid crystal cell 10 in this liquid crystal display is 380nm.

[0015] In drawing 26 , two or more concentric circles show the viewing angle, and the viewing angle of 0 degree (perpendicular to a screen) and the viewing angle on each circle of the center of a circle are 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees sequentially from a center side. Moreover, the angle value given to the circumference of a circle with a viewing angle of 50 degrees shows the direction, in the above-mentioned liquid crystal display, there is in the direction whose orientation processing direction 11a on the incidence side substrate 11 of a liquid crystal cell 10 is 0 degree of directions, and there is in the direction whose orientation processing direction 12a on the outgoing radiation side substrate 12 is 90 degrees of directions. In addition, transparency shaft 21a of a polarizer 21 has transparency shaft 22a of 90 degrees of directions, a 270-degree direction, and an analyzer 22 in 0 degree of directions, and the 180-degree direction.

[0016] and in the above-mentioned liquid crystal display, the value of Contrast CR like drawing 26 It is CR=200 on the contrast part wiring shown with CR=100 and the two-dot chain line on the contrast part wiring shown with CR=50 and the dashed line on the contrast part wiring shown by CR=10 and the dotted line on the contrast part wiring shown as the solid line. For example, the viewing angle from which the contrast of CR=200 is acquired is about 32 degrees in the time of seeing a display from [of a screen] a margo-inferior center (the direction of 315 degrees of directions).

[0017] In addition, the viewing angle when seeing the display of the above-mentioned liquid crystal display from [of a screen] a upper limb (the direction of 135 degrees of directions) Although the viewing angle from which the contrast of CR=200 is acquired is as small as about 8 degrees, the display of a liquid crystal display Since it is hardly observed from [of a screen] a upper limb, even if it is generally observed usually to a screen the direction of a transverse plane (the direction of a normal), or from [of a screen] the margo inferior, and the angle of visibility when seeing from [of a screen] a upper limb is small, there is especially no problem.

[0018] However, although the viewing angle from which the contrast of CR=200 when seeing the conventional liquid crystal display from [of a screen] a margo-inferior center is acquired is large enough, if it is put at about 32 degrees from across For example, the angle of visibility which the viewing angle from which the contrast of CR=200 is acquired becomes small with about 17 degrees when it sees to the direction of a margo-inferior center from a 45-degree direction (the direction of 0 degree of directions and 270 degrees of directions), therefore can see a display by good contrast is narrow.

[0019] And the above-mentioned liquid crystal display also has the problem that the change of a luminosity to change of the applied voltage when seeing in a big viewing angle will become reverse in a certain voltage range from a certain direction about a screen.

[0020] Namely, drawing 27 - drawing 29 Transparency shaft 21 of both substrates [of a liquid crystal cell 10] 11, orientation processing direction [on 12] a [11] and 12a, and polarizer 21 a and transparency shaft 22a of an analyzer 22 the relation between the inter-electrode applied voltage (effective voltage) to the liquid crystal cell 10 of the conventional liquid crystal display which tended to be shown in drawing 24 , and the luminosity (Y value) of a display It is the voltage-luminosity property view showing the result investigated about each viewing angle of 0 degree, 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees. A property when a property when drawing 27 looks at a display from a 135-degree direction, and drawing 28 look at a display from a 315-degree direction, and drawing 29 show the property when seeing a display from a 45-degree direction. In addition, the voltage-luminosity property when seeing a display from a 225-degree direction is almost the same as drawing 29 .

[0021] Like this drawing 27 - drawing 29 , the above-mentioned liquid crystal display Although there is especially no problem in the voltage-luminosity property when seeing from the direction of a upper limb (the direction of 135 degrees of directions) and longitudinal direction (the direction of 225 degrees of directions, and the direction of 45 degrees of directions) of a screen The voltage-luminosity property (property of drawing 28) when seeing from [of a screen] the margo inferior (the direction of 315

degrees of directions) If a viewing angle becomes larger than 40 degrees, in applied voltage once [2-4v] the luminosity of a display will be in a dark state, it will become bright again a little, and if applied voltage is made higher than it, it will become the property with the so-called "bump" of being in a dark state again.

[0022] And although the driver voltage of a liquid crystal display is generally set up based on the voltage-luminosity property with a viewing angle of 0 degree In a liquid crystal display with the above voltage-luminosity properties The inter-electrode voltage from which the inter-electrode voltage from which the luminosity when seeing a display in the viewing angle of 0 degree serves as the maximum is set to 0 - about 1.5v, and a luminosity is mostly set to "0" is about 3.5-4v. therefore, this liquid crystal display Since driver voltage is controlled and driven so that the minimum value of inter-electrode voltage may be set to 0 - about 1.5v and maximum may be set to about 3.5 to 4 v, the "bump" of the above-mentioned voltage-luminosity property is generated within the limits of the driver voltage of a liquid crystal display.

[0023] For this reason, when a screen was seen in a large viewing angle from a certain Mukai, "a flicker" arose in the display of a dark state, and reversal of gradation had produced the conventional liquid crystal display in the display of dark gradation in the gradation display.

[0024] " which a "bump" does not produce in a voltage-luminosity property with the direction and viewing angle which look at a screen while this invention can make the angle of visibility large, using a TN type liquid crystal cell -- it aims at offering the liquid crystal display which can obtain the quality display which flickers and has neither "nor reversal of gradation

[0025]

[Means for Solving the Problem] The liquid crystal display of this invention arranges a polarizer to the incidence side of the liquid crystal cell which the pneumatic liquid crystal was enclosed [liquid crystal cell] and carried out the twist array between the transparent substrates of the couple which carried out the laminating of the orientation film which regulates the direction of orientation of a liquid crystal molecule to the transparent electrode. While arranging an analyzer to the outgoing radiation side of the aforementioned liquid crystal cell, between at least one side of the aforementioned polarizer and an analyzer, and the aforementioned liquid crystal cell It comes to arrange the optical-axis tilt phase plate in which the lagging axis of a parenthesis carried out the tilt aslant [predetermined angle] to the normal with the lagging axis in the thickness direction. Make the direction of the orientation processing which gave the transparency shaft to the orientation film on the incidence side substrate of the aforementioned liquid crystal cell, and the aforementioned polarizer cross at right angles mostly, or make it parallel mostly and it is arranged. While the aforementioned analyzer's making the transparency shaft of the aforementioned polarizer, and the transparency shaft cross at right angles mostly, or making it parallel mostly and arranging it, the aforementioned optical-axis tilt phase plate It is characterized by making the orientation processing direction on the substrate which the aforementioned optical-axis tilt phase plate of the aforementioned liquid crystal cell adjoins, and the direction of a tilt of the lagging axis to the normal cross at right angles mostly, or making it parallel mostly and being arranged.

[0026] It is possible to form an optical-axis tilt phase plate in both between the aforementioned liquid crystal cell and an analyzer between a liquid crystal cell and polarizers, respectively, to make the direction of a tilt of a lagging axis [as opposed to the normal for both this optical-axis tilt phase plate] intersect perpendicularly mostly mutually as one embodiment of this invention, and to arrange.

[0027]

[Function] The linearly polarized light which carried out incidence through the polarizer is ****(ed) by the liquid crystal cell about 90 degrees in the polarization direction, and the liquid crystal display of this invention carries out incidence to an analyzer, when a display drive is carried out and OFF voltage is impressed to inter-electrode [of a liquid crystal cell] by impressing voltage to inter-electrode [of the above-mentioned liquid crystal cell] (i.e., when the array state of the liquid crystal molecule of a liquid crystal cell is in an early twist array state).

[0028] Moreover, incidence is carried out to an analyzer through [while the linearly polarized light which the **** operation in a liquid crystal layer was almost set to 0 when started a liquid crystal

molecule maintaining the twist array state from an early twist array state when ON voltage was impressed to inter-electrode / of a liquid crystal cell /, the **** operation in a liquid crystal layer became small, and the liquid crystal molecule started in the erection state mostly and having been arranged, and carried out incidence through the polarizer has been in the polarization state] a liquid crystal cell.

[0029] For this reason, also in this liquid crystal display, according to the voltage impressed to inter-electrode [of both liquid crystal cells], the light which passed along both liquid crystal cells penetrates an analyzer, or it is absorbed with an analyzer, and the display by light and darkness is obtained.

[0030] In this liquid crystal display and between at least one side of the aforementioned polarizer and an analyzer, and the aforementioned liquid crystal cell The optical-axis tilt phase plate in which the lagging axis of a parenthesis carried out the tilt aslant [predetermined angle] to the normal with the lagging axis is formed in the thickness direction. And since it was made to intersect perpendicularly with the direction of liquid crystal molecular orientation on the substrate which the aforementioned optical-axis tilt phase plate of the aforementioned liquid crystal cell adjoins mostly, or it was mostly made parallel and the direction of a tilt of a lagging axis [as opposed to the normal for this optical-axis tilt phase plate] is arranged, It becomes without a "bump" arising in a voltage-luminosity property with the direction and viewing angle which look at a screen, while an angle of visibility and a voltage-luminosity property are compensated and an angle of visibility becomes large with this optical-axis tilt phase plate.

[0031]

[Example] Hereafter, one example of this invention is explained with reference to drawing 1 - drawing 23 . Drawing 1 and drawing 2 are the decomposition perspective diagrams and cross sections of a liquid crystal display. This liquid crystal display element The TN liquid crystal cell 30, and a polarizer 41 and an analyzer 42, Consist of optical-axis tilt phase plates 43 and 44 of two sheets, and a polarizer 41 is arranged at the incidence side of a liquid crystal cell 30. An analyzer 42 is arranged at the outgoing radiation side of a liquid crystal cell 30. Moreover, the 1st optical-axis tilt phase plate (It is hereafter called an incidence photometry shaft tilt phase plate) 43 is prepared between a liquid crystal cell 30 and a polarizer 41, and the 2nd optical-axis tilt phase plate (henceforth an incidence photometry shaft tilt phase plate) 44 is formed between the liquid crystal cell 30 and the analyzer 42.

[0032] The above-mentioned liquid crystal cell 30 joins the transparent substrates 31 and 32 of a couple which consist of glass etc. through the frame-like sealant 37 in the periphery section, as shown in drawing 2 . It is what enclosed liquid crystal 38 with both this substrate 31 and the field surrounded by the sealant 37 between 32. The transparent electrodes 33 and 34 for impressing electric field to a liquid crystal layer, respectively are formed in the field where both the substrates 31 and 32 counter mutually, and the orientation films 35 and 36 which regulate the direction of orientation of a liquid crystal molecule are formed on it.

[0033] In addition, the above-mentioned orientation films 35 and 36 are level orientation films which consist of level orientation agents, such as a polyimide, and are LB film formed by carrying out the laminating of the monomolecular film by the LB (Langmuir BUROJETTO) method the rubbing processing film which formed the level orientation agent film on the substrate, and, on the other hand, carried out rubbing of the film surface to Mukai, or on the substrate.

[0034] With these orientation films 35 and 36, about 90 degrees (a rubbing processing film the direction of rubbing and LB film the direction of a list of a single molecule) of the orientation processing directions given to these orientation films 35 and 36 are shifted mutually, and where it has a certain pre tilt angle to the film surface, on the other hand, orientation of the liquid crystal molecule is carried out to Mukai, and they are carrying out the twist array on about 90-degree twist square between both the substrates 31 and 32.

[0035] That is, it sets to drawing 1 , in 31a and 32a, both the substrates 31 of a liquid crystal cell 30, the direction of liquid crystal molecular orientation on 32, and T show the liquid crystal molecule twist direction, and the liquid crystal molecule is carrying out the twist array on about 90-degree twist square in the clockwise direction [drawing top] toward the outgoing radiation side substrate 32 from the incidence side substrate 31.

[0036] The value of $\Delta n \cdot d$ (product of refractive-index anisotropy Δn of liquid crystal 38 and the

liquid crystal thickness d) to the vertical-incidence light in the state where the liquid crystal molecule of this liquid crystal cell 30 is carrying out twist orientation is 300-600nm. In addition, the thing of a segment method, or the thing and the thing of an active matrix method of a simple matrix method are sufficient as this liquid crystal cell 30.

[0037] On the other hand, in drawing 1, the transparency shaft of a polarizer 41 and 42a show the transparency shaft of an analyzer 42, and in this example, 41a made direction of liquid crystal molecular orientation 31a on the incidence side substrate 31 of a liquid crystal cell 30, and the transparency shaft 41a cross at right angles mostly, and arranges the polarizer 41.

[0038] Moreover, the liquid crystal display of this example is a positive display type thing, and the above-mentioned analyzer 42 makes transparency shaft 41a of the above-mentioned polarizer 41, and the transparency shaft 42a cross at right angles mostly, and is arranged.

[0039] Next, the above-mentioned optical-axis tilt phase plates 43 and 44 are explained. These optical-axis tilt phase plates 43 and 44 consist of a liquid crystal polymer which specified for example, the direction of molecular arrangement, and the lagging axis of a parenthesis is carrying out the tilt aslant [predetermined angle] to the normal with the lagging axis in the thickness direction.

[0040] Drawing 3 is the perspective diagram showing the lagging axis and phase leading shaft orientation of the above-mentioned optical-axis tilt phase plates 43 and 44, and is a lagging axis Z_{ne} . Only desired tilt angle θ leans in the predetermined direction x to the normal z of a phase plate side, and it is the phase leading shaft X_{no} . Lagging axis Z_{ne} It tends to intersect perpendicularly. In addition, the aforementioned lagging axis Z_{ne} Tilt angle θ is a larger value smaller than 90 degrees than 0 degree, and the normal-axis phase plate with which a $\theta = 0$ -degree phase plate has a lagging axis on Normal z , and the phase plate which is $\theta = 90$ degrees are the usual phase plates with which Normal z and a lagging axis tend to cross at right angles.

[0041] these optical-axis tilt phase plates 43 and 44 -- lagging axis Z_{ne} Rate n_e of an optical refraction in a direction Phase leading shaft X_{no} Rate n_o of an optical refraction in a direction It has decided refractive-index anisotropy $\Delta n'$ ($\Delta n' = n_e - n_o$), and the value of product $\Delta n' \cdot d'$ of refractive-index anisotropy $\Delta n'$ of these optical-axis tilt phase plates 43 and 44 and phase phase plate thickness d' is - 300-300nm. In addition, at this example, it is the phase leading shaft X_{no} of the optical-axis tilt phase plates 43 and 44. Refractive index n_o in a direction It is referred to as 1.581nm and is a lagging axis Z_{ne} . Refractive index n_e in a direction It adjusted and desired $\Delta n' \cdot d'$ has been obtained.

[0042] And these optical-axis tilt phase plates 43 and 44 are the lagging axes [respectively as opposed to the normal z] Z_{ne} . The orientation processing direction on the substrate which the aforementioned optical-axis tilt phase plates 43 and 44 of a liquid crystal cell 30 adjoin, and the direction of a tilt are made to cross at right angles mostly, or it is mostly made parallel and is arranged.

[0043] Namely, the incidence photometry shaft tilt phase plate 43 formed between the liquid crystal cell 30 and the polarizer 41 Lagging axis Z_{ne} to the normal z Make orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30, and the direction of a tilt cross at right angles mostly, or make it parallel mostly and it is arranged. The outgoing radiation photometry shaft tilt phase plate 44 formed between the liquid crystal cell 30 and the analyzer 42 Lagging axis Z_{ne} to the normal z Orientation processing direction 32a on the outgoing radiation side substrate 32 of a liquid crystal cell 30 and the direction of a tilt are made to cross at right angles mostly, or it is mostly made parallel, is arranged, and is the lagging axis Z_{ne} of both these optical-axis tilt phase plates 43 and 44. The direction of a tilt lies at right angles mostly mutually.

[0044] When this liquid crystal display impresses voltage between the electrode 33 of a liquid crystal cell 30, and 34, the light (for example, light from a back light) A which a display drive is carried out and carries out incidence to a liquid crystal display turns into the linearly polarized light through a polarizer 42, and carries out incidence to an analyzer 42 through the incidence photometry shaft tilt phase plate 43, a liquid crystal cell 30, and the outgoing radiation photometry shaft tilt phase plate 44.

[0045] And when OFF voltage is impressed between the electrode 33 of a liquid crystal cell 30, and 34 (i.e., when the array state of the liquid crystal molecule of a liquid crystal cell 30 is in an early twist array state), the linearly polarized light which carried out incidence through the polarizer 42 is ****(ed)

by the liquid crystal cell 30 about 90 degrees, and carries out incidence of the polarization direction to an analyzer 42 by it.

[0046] Moreover, start a liquid crystal molecule maintaining a twist array state from an early twist array state, if ON voltage is impressed between the electrode 33 of a liquid crystal cell 30, and 34, and a **** operation in a liquid crystal layer becomes small. If a liquid crystal molecule starts in the erection state mostly and arranges, a **** operation in a liquid crystal layer is almost set to 0, and while the linearly polarized light which carried out incidence through the polarizer 41 has been in the polarization state, incidence will be carried out to an analyzer 42 through a liquid crystal cell 30.

[0047] for this reason, with the liquid crystal display of the positive display type made to intersect perpendicularly mostly mutually, the transparency shafts 41a and 42a of a polarizer 41 and an analyzer 42 as mentioned above If OFF voltage is impressed between the electrode 33 of a liquid crystal cell 30, and 34, most light which passed along this portion penetrates an analyzer 42, and a display will be in the Ming state. If the electrode 33 of both the liquid crystal cells 30 and ON voltage which a liquid crystal molecule starts in the erection state mostly, and arranges among 34 are impressed, most light which passed along this portion is absorbed with an analyzer 42, and a display will be in a dark state.

[0048] Moreover, if the electrode 33 of a liquid crystal cell 30 and ON voltage in which a liquid crystal molecule changes orientation among 34 into the middle state of an early twist array state and an erection array state are impressed, a part of light which passed along this portion is absorbed with an analyzer 42, other light will penetrate an analyzer 42 and the luminosity of a display will become the middle gradation of the Ming state and a dark state.

[0049] And in this liquid crystal display, it reaches between a liquid crystal cell 30 and a polarizer 41. It has a lagging axis Zne in the thickness direction between the aforementioned liquid crystal cell 30 and an analyzer 42, respectively, and is the lagging axis Zne of a parenthesis. The optical-axis tilt phase plates 43 and 44 which carried out the tilt to Normal z are formed. And the incidence side tilt phase plate 43 is the lagging axis Zne. Make direction of liquid crystal molecular orientation 31a on the incidence side substrate 31 of a liquid crystal cell 30, and the direction of a tilt cross at right angles mostly, or make it parallel mostly and it arranges. The outgoing radiation photometry shaft tilt phase plate 44 is the lagging axis Zne. While making orientation processing direction 32a on the outgoing radiation side substrate 32 of a liquid crystal cell 30, and the direction of a tilt cross at right angles mostly, or making it parallel mostly and arranging Lagging axis Zne of both these optical-axis tilt phase plates 43 and 44 Since the direction of a tilt is made to intersect perpendicularly mostly mutually, It becomes without a "bump" arising in a voltage-luminosity property with the direction and viewing angle which look at a screen, while the angle of visibility of a liquid crystal display and a voltage-luminosity property are compensated and an angle of visibility becomes large with these optical-axis tilt phase plates 43 and 44.

[0050] An improvement of the angle of visibility by the above-mentioned optical-axis tilt phase plates 43 and 44 and a voltage-luminosity property can be attained by setting up lagging-axis tilt angle theta appropriately according to the value and the direction of a lagging-axis tilt of $\delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44. Below, the concrete example is explained.

[0051] [Example 1] This example the value of $\delta n \cdot d$ of a liquid crystal cell 30 380nm, The value of $\delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is set to -50nm. It is the example which carried out the direction of a lagging-axis tilt at the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, each orientation processing directions 31a and 32a on 32, and parallel, respectively, and has arranged the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation. Each lagging axis Zne of the optical-axis tilt phase plates 43 and 44 Tilt angle theta is made into 40 degrees.

[0052] Drawing 4 shows the relation with the contrast CR of the viewing angle in this liquid crystal display and its direction, and a display. In drawing 4, two or more concentric circles show the viewing angle, and the viewing angle of 0 degree (perpendicular to a screen) and the viewing angle on each circle of the center of a circle are 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees sequentially from a center side. Moreover, the angle value given to the circumference of a circle with a

viewing angle of 50 degrees shows the direction, and there is in the direction whose orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30 is 0 degree of directions, and the direction whose orientation processing direction 32a on the outgoing radiation side substrate 32 is 90 degrees of directions in this liquid crystal display. In addition, there is transparency shaft 41a of a polarizer 41 in the direction of 90 degrees of directions, and there is transparency shaft 42a of an analyzer 42 in the direction of 0 degree of directions.

[0053] Moreover, it sets to drawing 4 and 43x are the lagging axis Zne of the incidence photometry shaft tilt phase plate 43. The direction of a tilt, 44x are the lagging axis Zne of the outgoing radiation photometry shaft tilt phase plate 44. The direction of a tilt is shown. Direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 The direction of 0 degree of directions, Namely, it is in orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30, and this direction (and same direction). Direction of lagging-axis tilt 44x of the outgoing radiation photometry shaft tilt phase plate 44 are in the direction of 270 degrees of directions, i.e., orientation processing direction 32a and the opposite direction (and retrose) on the outgoing radiation side substrate 32 of a liquid crystal cell 30.

[0054] So that it may understand, if drawing 26 which indicated the viewing angle of the conventional liquid crystal display and the relation with the contrast CR of the direction and a display to be this drawing 4 is compared the liquid crystal display of the above [an example 1] The viewing angle from which the contrast of CR=200 is acquired in the time of seeing from [of a screen] a lower marginal center (the direction of 315 degrees of directions) For example, about 27 degrees, It is as large as about 32 degrees enough at the time of seeing to the direction of a lower marginal center from a 45-degree direction (the direction of 0 degree of directions, and 270 degrees of directions), and the angle of visibility which can see a display by good contrast is large in almost all the directions compared with the conventional liquid crystal display.

[0055] In addition, although the angle of visibility when also seeing this liquid crystal display from [of a screen] a upper limb (the direction of 135 degrees of directions) hardly changes with the conventional liquid crystal display, as the term of [Problem(s) to be Solved by the Invention] also explained Since it is hardly observed from [of a screen] a upper limb, even if it is common to be observed to a screen from the direction of a transverse plane (the direction of a normal), the direction of the margo inferior of a screen, or a longitudinal direction as for the display of a liquid crystal display, and the angle of visibility when seeing from [of a screen] a upper limb is small, there is especially no problem.

[0056] Drawing 5 - drawing 7 moreover, the relation between the inter-electrode applied voltage (V) to the liquid crystal cell 10 of the liquid crystal display of the above [an example 1], and the luminosity (Y value) of a display It is the voltage-luminosity property view showing the result investigated about each viewing angle of 0 degree, 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees. The property when seeing a property when drawing 5 looks at a display for a display from a 135-degree direction, and drawing 6 from a 315-degree direction, and drawing 7 show the property when seeing from a 45-degree direction. In addition, the voltage-luminosity property when seeing from a 225-degree direction is almost the same as drawing 7.

[0057] Although a "bump" arises in the conventional liquid crystal display in the voltage-luminosity property (property of drawing 24) when seeing from [of a screen] a lower edge (the direction of 315 degrees of directions) so that it may understand, if this drawing 5 - drawing 7 are compared with drawing 23 which showed the voltage-luminosity property of the conventional liquid crystal display - drawing 25 A screen the liquid crystal display of the above [an example 1] the direction of a upper limb (the direction of 135 degrees of directions) the voltage-luminosity property (property of drawing 5) when seeing The voltage-luminosity property (property of drawing 7) when seeing from the longitudinal direction (the direction of 225 degrees of directions, and the direction of 45 degrees of directions) of a screen the property that not all the voltage-luminosity properties (property of drawing 6) when seeing from [of a screen] a lower edge (the direction of 315 degrees of directions) also have a "bump" -- it is -- therefore, -- the quality display which flickers and has neither "nor reversal of gradation can be obtained

[0058] In addition, although lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was made into 40 degrees in this example. The value of $\Delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is -50nm as mentioned above. When the direction of a lagging-axis tilt of the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation is parallel to the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, and the directions 31a and 32a of liquid crystal molecular orientation on 32 respectively. If lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is the range which is about 30-70 degrees, the voltage-luminosity property when seeing a screen from which direction will also turn into a property without a "bump."

[0059] Namely, the value of $\Delta n \cdot d$ of a liquid crystal cell 30 is [the value of drawing 8 of $\Delta n \cdot d$ of 380nm and the optical-axis tilt phase plates 43 and 44] -50nm. The direction whose direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 are 0 degree of directions, About the liquid crystal display which exists in the direction whose direction of lagging-axis tilt 44x of the outgoing radiation photometry shaft tilt phase plate 44 are 270 degrees of directions. The result which lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was changed, and investigated change of the luminosity (Y value) of a display is shown. here The voltage of 3v is impressed to inter-electrode [of a liquid crystal cell 30], and the change of the luminosity of a display to lagging-axis tilt angle θ when seeing the display of a liquid crystal display element from [of a screen] the margo inferior (the direction of 315 degrees of directions) is shown.

[0060] In addition, in drawing 8, the tilt angle to the right direction (the incidence photometry shaft tilt phase plate 43 the direction of 0 degree of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 270 degrees of directions) and negative lagging-axis tilt angle θ of positive lagging-axis tilt angle θ are the tilt angles to an opposite direction (the incidence photometry shaft tilt phase plate 43 the direction of 180 degrees of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 90 degrees of directions).

[0061] Like this drawing 8, the luminosity of a display in the range whose lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is about 30-70 degrees is almost "0", therefore the above-mentioned liquid crystal display becomes the property that a voltage-luminosity property does not have a "bump."

[0062] Moreover, it is a property as the voltage-luminosity property when seeing a screen from the direction of a lower edge and a longitudinal direction showed to drawing 6 and drawing 7 in the above-mentioned liquid crystal display. Although the luminosity of a display when a viewing angle is larger than 30 degrees increases a luminosity slightly again in connection with applied voltage becoming higher than about 3.5 v once it will be in a dark state. In this liquid crystal display, since the inter-electrode voltage from which the luminosity when seeing a display in the viewing angle of 0 degree is mostly set to "0" is about 3.5v, if the highest value of applied voltage is set as about 3.5v, the phenomenon in which the change of a luminosity to change of applied voltage becomes reverse at a high-voltage side will not be produced. This is the same also in the liquid crystal display of following [example 2] - [an example 4].

[0063] [an example 2] -- this example is the same as the above [an example 1] in the value of $\Delta n \cdot d$ of a liquid crystal cell 30, and $\Delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44]' ($\Delta n \cdot d = -380\text{nm}$) It is made Δn and $d = -50\text{nm}$. the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation, respectively. It is the example which the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, each orientation processing directions 31a and 32a on 32, and the direction of a lagging-axis tilt were made to cross at right angles, and has arranged it, and is the lagging axis Zne of the optical-axis tilt phase plates 43 and 44 in that case. Tilt angle θ is made into 40 degrees.

[0064] Drawing 9 shows the relation with the contrast CR of the viewing angle in the above-mentioned liquid crystal display and its direction, and a display. in this liquid crystal display. The direction whose direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 are 270 degrees of directions, Namely, 90 degrees tended to have shifted in the clockwise direction [drawing top] to orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30. 90

degrees tended to have shifted in the clockwise direction [drawing top] to orientation processing direction 32a on direction of lagging-axis tilt 44 the direction 32 whose x is 0 degree of directions, i.e., the outgoing radiation side substrate of a liquid crystal cell 30, of the outgoing radiation photometry shaft tilt phase plate 44.

[0065] So that this drawing 9 may show the liquid crystal display of the above [an example 2] The viewing angle from which the contrast of $CR=200$ is acquired in the time of seeing from [of a screen] a lower marginal center (the direction of 315 degrees of directions) For example, about 27 degrees, It is as large as about 28 degrees enough at the time of seeing to the direction of a lower marginal center from a 45-degree direction (the direction of 0 degree of directions, and 270 degrees of directions), and has a far large angle of visibility compared with the conventional liquid crystal display.

[0066] Drawing 10 - drawing 12 moreover, the relation between the inter-electrode applied voltage (V) to the liquid crystal cell 10 of the liquid crystal display of the above [an example 2], and the luminosity (Y value) of a display It is the voltage-luminosity property view showing the result investigated about each viewing angle of 0 degree, 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees. The property when seeing a property when drawing 10 looks at a display for a display from a 135-degree direction, and drawing 11 from a 315-degree direction, and drawing 12 show the property when seeing from a 45-degree direction. In addition, the voltage-luminosity property when seeing from a 225-degree direction is almost the same as drawing 12 .

[0067] The liquid crystal display of the above [an example 2] is the property that the voltage-luminosity property when seeing a screen from which direction does not have a "bump", either, therefore can obtain the quality display without "a flicker" and reversal of gradation so that this drawing 10 - drawing 12 may show.

[0068] In addition, although lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was made into 40 degrees in this example The value of $\delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is -50nm as mentioned above. When the direction of a lagging-axis tilt of the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation lies at right angles to the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, and the directions 31a and 32a of liquid crystal molecular orientation on 32, respectively If lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is the range which is about 35-85 degrees, the voltage-luminosity property when seeing a screen from which direction will also turn into a property without a "bump."

[0069] The value of $\delta n \cdot d$ of a liquid crystal cell 30 is [the value of drawing 13 of $\delta n \cdot d$ of 380nm and the optical-axis tilt phase plates 43 and 44] -50nm. The direction whose direction of lagging-axis tilt $43x$ of the incidence photometry shaft tilt phase plate 43 are 270 degrees of directions, About the liquid crystal display which exists in the direction whose direction of lagging-axis tilt $44x$ of the outgoing radiation photometry shaft tilt phase plate 44 are 0 degree of directions The result which lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was changed, and investigated change of the luminosity (Y value) of a display is shown. here The voltage of 3v is impressed to inter-electrode [of a liquid crystal cell 30], and the change of the luminosity of a display to lagging-axis tilt angle θ when seeing the display of a liquid crystal display element from [of a screen] a lower edge (the direction of 315 degrees of directions) is shown.

[0070] In addition, in drawing 13 , the tilt angle to the right direction (the incidence photometry shaft tilt phase plate 43 the direction of 270 degrees of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 0 degree of directions) and negative lagging-axis tilt angle θ of positive lagging-axis tilt angle θ are the tilt angles to an opposite direction (the incidence photometry shaft tilt phase plate 43 the direction of 90 degrees of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 180 degrees of directions).

[0071] Like this drawing 13 , the luminosity of a display in the range whose lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is 35-85 degrees is almost "0", therefore the above-mentioned liquid crystal display becomes the property that a voltage-luminosity property does not have a "bump."

[0072] [Example 3] This example the value of $\delta n \cdot d$ of a liquid crystal cell 30 is 380nm. The value of $\delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is set to +50nm. It is the example which carried out the direction of a lagging-axis tilt at the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, each orientation processing directions 31a and 32a on 32, and parallel, respectively, and has arranged the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation. In this case, lagging axis Zne of the optical-axis tilt phase plates 43 and 44 Tilt angle θ is made into 70 degrees.

[0073] Drawing 14 shows the relation with the contrast CR of the viewing angle in the above-mentioned liquid crystal display and its direction, and a display. In this liquid crystal display The direction whose direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 are 180 degrees of directions, Namely, it is in orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30, and an opposite direction (and retrose). It is in orientation processing direction 32a on direction of lagging-axis tilt 44 the direction 32 whose x is 90 degrees of directions, i.e., the outgoing radiation side substrate of a liquid crystal cell 30, of the outgoing radiation photometry shaft tilt phase plate 44, and this direction (and same direction).

[0074] So that this drawing 14 may show the liquid crystal display of the above [an example 3] The viewing angle from which the contrast of $CR=200$ is acquired in the time of seeing from [of a screen] a lower marginal center (the direction of 315 degrees of directions) For example, about 29 degrees, It is as large as about 21 degrees enough at the time of seeing to the direction of a lower marginal center from a 45-degree direction (the direction of 0 degree of directions, and 270 degrees of directions), and has a far large angle of visibility compared with the conventional liquid crystal display.

[0075] Drawing 15 - drawing 17 moreover, the relation between the inter-electrode applied voltage (V) to the liquid crystal cell 10 of the liquid crystal display of the above [an example 3], and the luminosity (Y value) of a display It is the voltage-luminosity property view showing the result investigated about each viewing angle of 0 degree, 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees. The property when seeing a property when drawing 15 looks at a display for a display from a 135-degree direction, and drawing 16 from a 315-degree direction, and drawing 17 show the property when seeing from a 45-degree direction. In addition, the voltage-luminosity property when seeing from a 225-degree direction is almost the same as drawing 17.

[0076] The liquid crystal display of the above [an example 3] is the property that the voltage-luminosity property when seeing a screen from which direction does not have a "bump", either, therefore can obtain the quality display without "a flicker" and reversal of gradation so that this drawing 15 - drawing 17 may show.

[0077] In addition, although lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was made into 70 degrees in this example The value of $\delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is +50nm as mentioned above. When the direction of a lagging-axis tilt of the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation is parallel to the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, and the directions 31a and 32a of liquid crystal molecular orientation on 32 respectively If lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is the range which is about 60-80 degrees, the voltage-luminosity property when seeing a screen from which direction will also turn into a property without a "bump."

[0078] The value of $\delta n \cdot d$ of a liquid crystal cell 30 is [the value of drawing 18 of $\delta n \cdot d$ of 380nm and the optical-axis tilt phase plates 43 and 44] +50nm. The direction whose direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 are 180 degrees of directions, About the liquid crystal display which exists in the direction whose direction of lagging-axis tilt 44x of the outgoing radiation photometry shaft tilt phase plate 44 are 90 degrees of directions The result which lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was changed, and investigated change of the luminosity (Y value) of a display is shown. here The voltage of 3v is impressed to inter-electrode [of a liquid crystal cell 30], and the change of the luminosity of a display to lagging-axis tilt angle θ when seeing the display of a liquid crystal display element from [of a screen] the margo inferior (the direction of 315 degrees of directions) is shown.

[0079] In addition, in drawing 18, the tilt angle to the right direction (the incidence photometry shaft tilt phase plate 43 the direction of 180 degrees of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 90 degrees of directions) and negative lagging-axis tilt angle θ of positive lagging-axis tilt angle θ are the tilt angles to an opposite direction (the incidence photometry shaft tilt phase plate 43 the direction of 0 degree of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 270 degrees of directions).

[0080] Like this drawing 18, the luminosity of a display in the range whose lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is 60-80 degrees is almost "0", therefore the above-mentioned liquid crystal display becomes the property that a voltage-luminosity property does not have a "bump."

[0081] [Example 4] This example the value of $\Delta n \cdot d$ of a liquid crystal cell 30 380nm, The value of $\Delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is set to +50nm. It is the example which the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, each orientation processing directions 31a and 32a on 32, and the direction of a lagging-axis tilt were made to cross at right angles, and has arranged the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation, respectively. In this case, lagging axis Zne of the optical-axis tilt phase plates 43 and 44 Tilt angle θ is made into 50 degrees.

[0082] Drawing 19 shows the relation with the contrast CR of the viewing angle in the above-mentioned liquid crystal display and its direction, and a display. in this liquid crystal display The direction whose direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 are 90 degrees of directions, Namely, 90 degrees tended to have shifted in the counterclockwise direction [drawing top] to direction of liquid crystal molecular orientation 31a on the incidence side substrate 31 of a liquid crystal cell 30. 90 degrees tended to have shifted in the counterclockwise direction [drawing top] to direction of liquid crystal molecular orientation 32a on direction of lagging-axis tilt 44 the direction 32 whose x is 180 degrees of directions, i.e., the outgoing radiation side substrate of a liquid crystal cell 30, of the outgoing radiation photometry shaft tilt phase plate 44.

[0083] So that this drawing 19 may show the liquid crystal display of the above [an example 4] The viewing angle from which the contrast of $CR=200$ is acquired in the time of seeing from [of a screen] a lower marginal center (the direction of 315 degrees of directions) For example, about 25 degrees, It is as large as about 32 degrees enough at the time of seeing to the direction of a lower marginal center from a 45-degree direction (the direction of 0 degree of directions, and 270 degrees of directions), and has a far large angle of visibility compared with the conventional liquid crystal display.

[0084] Drawing 20 - drawing 22 moreover, the relation between the inter-electrode applied voltage (V) to the liquid crystal cell 10 of the liquid crystal display of the above [an example 4], and the luminosity (Y value) of a display It is the voltage-luminosity property view showing the result investigated about each viewing angle of 0 degree, 10 degrees, 20 degrees, 30 degrees, 40 degrees, and 50 degrees. The property when seeing a property when drawing 20 looks at a display for a display from a 135-degree direction, and drawing 21 from a 315-degree direction, and drawing 22 show the property when seeing from a 45-degree direction. In addition, the voltage-luminosity property when seeing from a 225-degree direction is almost the same as drawing 22.

[0085] The liquid crystal display of the above [an example 4] is the property that the voltage-luminosity property when seeing a screen from which direction does not have a "bump", either, therefore can obtain the quality display without "a flicker" and reversal of gradation so that this drawing 20 - drawing 22 may show.

[0086] In addition, although lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was made into 50 degrees in this example The value of $\Delta n \cdot d$ of the optical-axis tilt phase plates 43 and 44 is +50nm as mentioned above. When the direction of a lagging-axis tilt of the optical-axis tilt phase plates 43 and 44 by the side of incidence and outgoing radiation lies at right angles to the incidence side of a liquid crystal cell 30 and the outgoing radiation side substrate 31, and each orientation processing directions 31a and 32a on 32, respectively If lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is the range which is about 40-60 degrees, the voltage-luminosity

property when seeing a screen from which direction will also turn into a property without a "bump."

[0087] The value of $\Delta n \cdot d$ of a liquid crystal cell 30 is [the value of drawing 23 of $\Delta n \cdot d$ of 380nm and the optical-axis tilt phase plates 43 and 44] +50nm. The direction whose direction of lagging-axis tilt 43x of the incidence photometry shaft tilt phase plate 43 are 90 degrees of directions, About the liquid crystal display which exists in the direction whose direction of lagging-axis tilt 44x of the outgoing radiation photometry shaft tilt phase plate 44 are 180 degrees of directions The result which lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 was changed, and investigated change of the luminosity (Y value) of a display is shown. here The voltage of 3v is impressed to inter-electrode [of a liquid crystal cell 30], and the change of the luminosity of a display to lagging-axis tilt angle θ when seeing the display of a liquid crystal display element from [of a screen] the margo inferior (the direction of 315 degrees of directions) is shown.

[0088] In addition, in drawing 23 , the tilt angle to the right direction (the incidence photometry shaft tilt phase plate 43 the direction of 90 degrees of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 180 degrees of directions) and negative lagging-axis tilt angle θ of positive lagging-axis tilt angle θ are the tilt angles to an opposite direction (the incidence photometry shaft tilt phase plate 43 the direction of 270 degrees of directions and the outgoing radiation photometry shaft tilt phase plate 44 the direction of 0 degree of directions).

[0089] Like this drawing 23 , the luminosity of a display in the range whose lagging-axis tilt angle θ of the optical-axis tilt phase plates 43 and 44 is 40-60 degrees is almost "0", therefore the above-mentioned liquid crystal display becomes the property that a voltage-luminosity property does not have a "bump."

[0090] Thus, since a "bump" does not arise in a voltage-luminosity property with the direction and viewing angle which look at a screen, using a TN type liquid crystal cell while being able to make the angle of visibility large, the liquid crystal display of the above-mentioned example can obtain the quality display without "a flicker" and reversal of gradation.

[0091] In addition, although orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30 and the transparency shaft 41a were made to cross at right angles mostly and the polarizer 41 is arranged in the above-mentioned example, transparency shaft 41a of this polarizer 41 may be almost parallel to orientation processing direction 31a on the incidence side substrate 31 of a liquid crystal cell 30, and the same effect as the above-mentioned example is acquired also by that case.

[0092] Moreover, although the liquid crystal display of the above-mentioned example is the positive display type thing which made the transparency shafts 41a and 42a of a polarizer 41 and an analyzer 42 intersect perpendicularly mostly mutually, it may be the thing of the negative display type which the liquid crystal display of this invention set the transparency shaft 42a to transparency shaft 41a of a polarizer 41 mostly at parallel, and has arranged the analyzer 42.

[0093] Furthermore, in the above-mentioned example, although the optical-axis tilt phase plates 43 and 44 were formed in both between the aforementioned liquid crystal cell 30 and an analyzer 42 between a liquid crystal cell 30 and polarizers 41, respectively, you may form an optical-axis tilt phase plate only between at least one side of a polarizer 41 and an analyzer 42, and a liquid crystal cell 30.

[0094]

[Effect of the Invention] The liquid crystal display of this invention arranges a polarizer to the incidence side of the liquid crystal cell which the pneumatic liquid crystal was enclosed [liquid crystal cell] and carried out the twist array between the transparent substrates of the couple which carried out the laminating of the orientation film which regulates the direction of orientation of a liquid crystal molecule to the transparent electrode. While arranging an analyzer to the outgoing radiation side of the aforementioned liquid crystal cell, between at least one side of the aforementioned polarizer and an analyzer, and the aforementioned liquid crystal cell It comes to arrange the optical-axis tilt phase plate in which the lagging axis of a parenthesis carried out the tilt aslant [predetermined angle] to the normal with the lagging axis in the thickness direction. Make the direction of the orientation processing which gave the transparency shaft to the orientation film on the incidence side substrate of the aforementioned liquid crystal cell, and the aforementioned polarizer cross at right angles mostly, or make it parallel

mostly and it is arranged. While the aforementioned analyzer's making the transparency shaft of the aforementioned polarizer, and the transparency shaft cross at right angles mostly, or making it parallel mostly and arranging it, the aforementioned optical-axis tilt phase plate Since it is characterized by making the orientation processing direction on the substrate which the aforementioned optical-axis tilt phase plate of the aforementioned liquid crystal cell adjoins, and the direction of a tilt of the lagging axis to the normal cross at right angles mostly, or making it parallel mostly and being arranged It can carry out without a "bump" arising in a voltage-luminosity property with the direction and viewing angle which look at a screen, using a TN type liquid crystal cell, while being able to make the angle of visibility large, and the quality display without "a flicker" and reversal of gradation can be obtained.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] Generally the thing using the TN (Twisted Nematic) type liquid crystal cell as a liquid crystal display is used. Drawing 24 and drawing 25 are the conventional decomposition perspective diagrams and cross sections of a liquid crystal display, and this liquid crystal display element consists of a TN liquid crystal cell 10, a polarizer 21 arranged at the incidence side of the light A to this liquid crystal cell 10, and an analyzer 22 arranged at the outgoing radiation side of the aforementioned liquid crystal cell 10.

[0003] The above-mentioned liquid crystal cell 10 joins the transparent substrates 11 and 12 of a couple which consist of glass etc. through the frame-like sealant 17 in the periphery section, as shown in drawing 25. It is what enclosed liquid crystal 18 with both this substrate 11 and the field surrounded by the sealant 17 between 12. The transparent electrodes 13 and 14 for impressing electric field to a liquid crystal layer, respectively are formed in the field where both the substrates 11 and 12 counter mutually, and the orientation films 15 and 16 which regulate the direction of orientation of a liquid crystal molecule are formed on it.

[0004] And with these orientation films 15 and 16, about 90 degrees of the orientation regulation directions to the liquid crystal molecule by the above-mentioned orientation films 15 and 16 are shifted mutually, and where it has a certain pre tilt angle to the film surface, on the other hand, orientation of the liquid crystal molecule is carried out to **, and it is carrying out the twist array on about 90-degree twist square between both the substrates 11 and 12.

[0005] That is, it sets to drawing 24, in the direction of liquid crystal molecular orientation on (the 15th page of orientation film) the incidence side substrate 11 of a liquid crystal cell 10, and 12a, the direction of liquid crystal molecular orientation on (the 16th page of orientation film) the outgoing radiation side substrate 12 and T show [11a] the twist direction of a liquid crystal molecule, and the liquid crystal molecule is carrying out the twist array on about 90-degree twist square in the clockwise direction toward the outgoing radiation side substrate 12 from the incidence side substrate 11. In addition, generally as the above-mentioned liquid crystal cell 10, that whose value of product $\Delta n \cdot d$ of refractive-index anisotropy Δn of liquid crystal 18 and the liquid crystal thickness d is 350-450nm is used.

[0006] On the other hand, in 21a, the transparency shaft of a polarizer 21 and 22a show the transparency shaft of the above-mentioned analyzer 22 in drawing 24. a polarizer 21 Direction of liquid crystal molecular orientation 11a on the incidence side substrate 11 of a liquid crystal cell 10 and the transparency shaft 21a are made to cross at right angles mostly, or it is mostly made parallel and is arranged. an analyzer 22 Transparency shaft 21a of the aforementioned polarizer 21 and the transparency shaft 22a are made to cross at right angles mostly, or it is mostly made parallel and is arranged.

[0007] In addition, the transparency shafts 21a and 22a were made for a polarizer 21 and an analyzer 22 to intersect perpendicularly mostly mutually like [a thing a positive display type thing and negative display type is shown in the liquid crystal display using a TN liquid crystal cell, and / in a positive display type liquid crystal display] drawing 24, it has arranged, the transparency shafts 21a and 22a of

each other were mostly made parallel for the polarizer 21 and the analyzer 22 in the negative display type liquid crystal display, and it arranges.

[0008] The above-mentioned liquid crystal displays are the electrode 13 of a liquid crystal cell 10, and the thing by which a display drive is carried out by impressing voltage among 14 by impressing electric field to the inter-electrode liquid crystal layer. When OFF voltage is impressed between an electrode 13 and 14 (i.e., when the array state of a liquid crystal molecule is in an early twist array state), the linearly polarized light which carried out incidence to the liquid crystal cell 10 through the polarizer 21 is **** (ed) about 90 degrees, and carries out incidence of the polarization direction to an analyzer 22.

[0009] Moreover, start a liquid crystal molecule maintaining a twist array state from an early twist array state, if ON voltage is impressed between the electrode 13 of a liquid crystal cell 10, and 14, and a **** operation in a liquid crystal layer becomes small. If a liquid crystal molecule starts in the erection state mostly and arranges, a **** operation in a liquid crystal layer is almost set to 0, and while the linearly polarized light which carried out incidence through the polarizer 21 has been in the polarization state, incidence will be carried out to an analyzer 22 through a liquid crystal cell.

[0010] For this reason, in the liquid crystal display of the positive display type which is making the transparency shafts 21a and 22a intersect perpendicularly mostly mutually of a polarizer 21 and an analyzer 22 Most light which passed along this portion when OFF voltage was impressed between the electrode 13 of a liquid crystal cell 10 and 14 penetrates an analyzer 22, and a display will be in the Ming state, and if ON voltage which a liquid crystal molecule starts in the erection state mostly, and is arranged is impressed Most light which passed along this portion is absorbed with an analyzer 22, and a display will be in a dark state.

[0011] Moreover, if ON voltage in which a liquid crystal molecule changes orientation into the middle state of an early twist array state and an erection array state is impressed, a part of light which passed along this portion is absorbed with an analyzer 22, other light will penetrate an analyzer 22 and the luminosity of a display will become the middle gradation of the Ming state and a dark state.

[0012] In addition, the thing using the liquid crystal cell of the segment method which formed in the above-mentioned liquid crystal display the common electrode which forms the segment electrode of the configuration corresponding to a display pattern in one substrate, and counters the substrate of another side with the aforementioned segment electrode, The thing using the liquid crystal cell of the simple matrix method which formed two or more scanning electrodes of each other in one substrate in parallel, and the aforementioned scanning electrode and the substrate of another side were made to cross at right angles, and formed two or more signal electrodes, There is a thing using the liquid crystal cell of the active matrix method which carried out array formation of two or more pixel electrodes and its active elements (for example, TFT etc.) in the line writing direction and the direction of a train, and formed the counterelectrode in one substrate at the substrate of another side.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The decomposition perspective diagram of the liquid crystal display by one example of this invention.

[Drawing 2] The cross section of this liquid crystal display.

[Drawing 3] The perspective diagram showing the lagging axis and phase leading shaft orientation of an optical-axis tilt phase plate

[Drawing 4] Drawing showing the relation between the viewing angle in the liquid crystal display of [an example 1] and its direction, and the contrast of a display.

[Drawing 5] The voltage-luminosity property view when seeing a display from the 135-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 6] The voltage-luminosity property view when seeing a display from the 315-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 7] The voltage-luminosity property view when seeing a display from the 45-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 8] Drawing showing the relation of the lagging-axis tilt angle of an optical-axis tilt phase plate and the luminosity of a display in this liquid crystal display.

[Drawing 9] Drawing showing the relation between the viewing angle in the liquid crystal display of [an example 2] and its direction, and the contrast of a display.

[Drawing 10] The voltage-luminosity property view when seeing a display from the 135-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 11] The voltage-luminosity property view when seeing a display from the 315-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 12] The voltage-luminosity property view when seeing a display from the 45-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 13] Drawing showing the relation of the lagging-axis tilt angle of an optical-axis tilt phase plate and the luminosity of a display in this liquid crystal display.

[Drawing 14] Drawing showing the relation between the viewing angle in the liquid crystal display of [an example 3] and its direction, and the contrast of a display.

[Drawing 15] The voltage-luminosity property view when seeing a display from the 135-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to

a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 16] The voltage-luminosity property view when seeing a display from the 315-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 17] The voltage-luminosity property view when seeing a display from the 45-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 18] Drawing showing the relation of the lagging-axis tilt angle of an optical-axis tilt phase plate and the luminosity of a display in this liquid crystal display.

[Drawing 19] Drawing showing the relation between the viewing angle in the liquid crystal display of [an example 4] and its direction, and the contrast of a display.

[Drawing 20] The voltage-luminosity property view when seeing a display from the 135-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 21] The voltage-luminosity property view when seeing a display from the 315-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 22] The voltage-luminosity property view when seeing a display from the 45-degree direction which shows the result which investigated the relation of the inter-electrode applied voltage to a liquid crystal cell and the luminosity of a display in this liquid crystal display about each viewing angle.

[Drawing 23] Drawing showing the relation of the lagging-axis tilt angle of an optical-axis tilt phase plate and the luminosity of a display in this liquid crystal display.

[Drawing 24] The decomposition perspective diagram of the conventional liquid crystal display.

[Drawing 25] The cross section of the conventional liquid crystal display.

[Drawing 26] Drawing showing the relation between the viewing angle in the conventional liquid crystal display and its direction, and the contrast of a display.

[Drawing 27] The voltage-luminosity property view when seeing a display from the 135-degree direction which shows the result which investigated the relation between the inter-electrode applied voltage to the liquid crystal cell of the conventional liquid crystal display, and the luminosity of a display about each viewing angle.

[Drawing 28] The voltage-luminosity property view when seeing a display from the 315-degree direction which shows the result which investigated the relation between the inter-electrode applied voltage to the liquid crystal cell of the conventional liquid crystal display, and the luminosity of a display about each viewing angle.

[Drawing 29] The voltage-luminosity property view when seeing a display from the 45-degree direction which shows the result which investigated the relation between the inter-electrode applied voltage to the liquid crystal cell of the conventional liquid crystal display, and the luminosity of a display about each viewing angle.

[Description of Notations]

30 -- TN liquid crystal cell

31 -- Incidence side substrate

32 -- Outgoing radiation side substrate

33 34 -- Transparent electrode

35 36 -- Orientation film

38 -- Liquid crystal

31a -- The orientation processing direction on the incidence side substrate of a liquid crystal cell

32a -- The orientation processing direction on the outgoing radiation side substrate of a liquid crystal

cell

T -- The liquid crystal molecule twist direction of a liquid crystal cell

41 -- Polarizer

41a -- Transparency shaft

42 -- Analyzer

42a -- Transparency shaft

43 44 -- Optical-axis tilt phase plate

43a, 44a -- Lagging axis

[Translation done.]

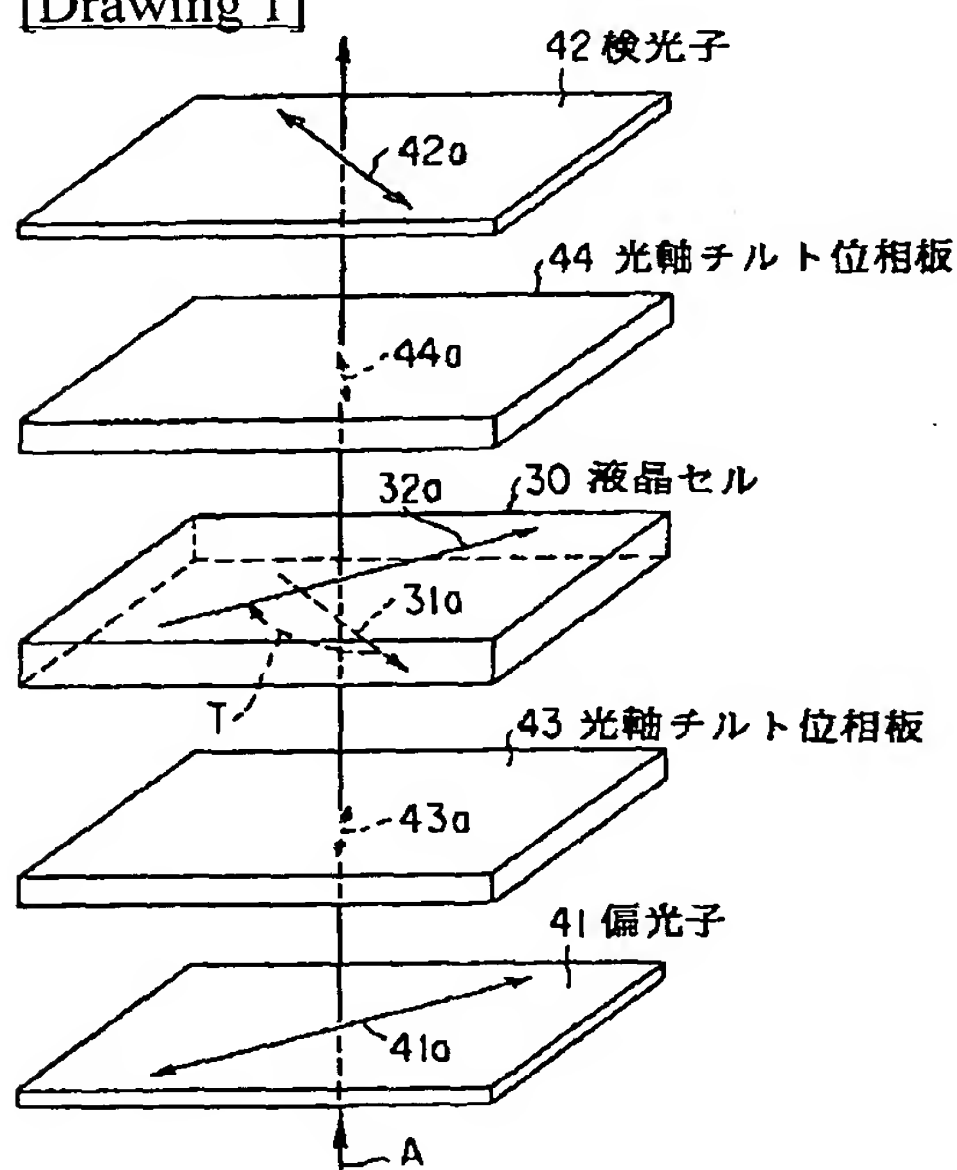
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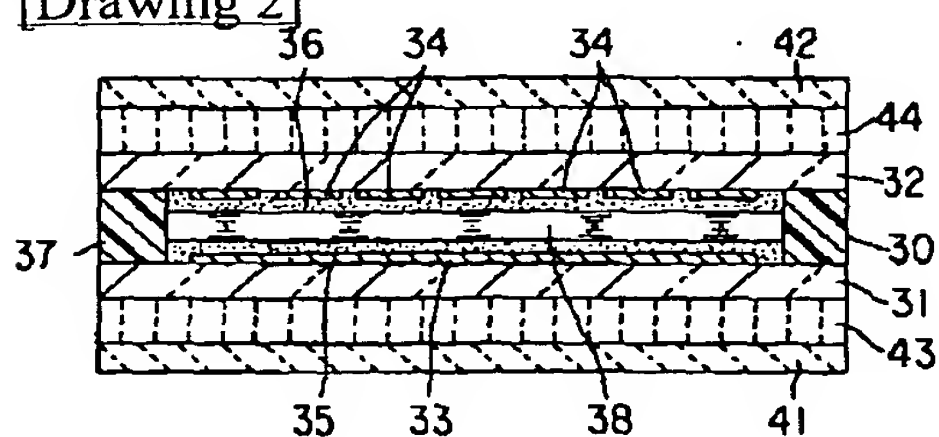
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

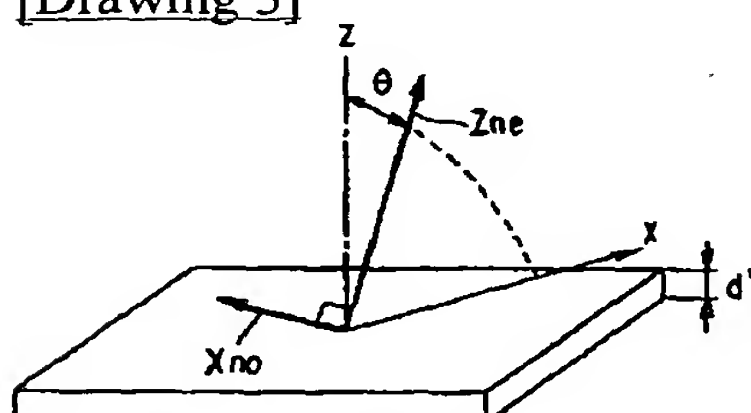
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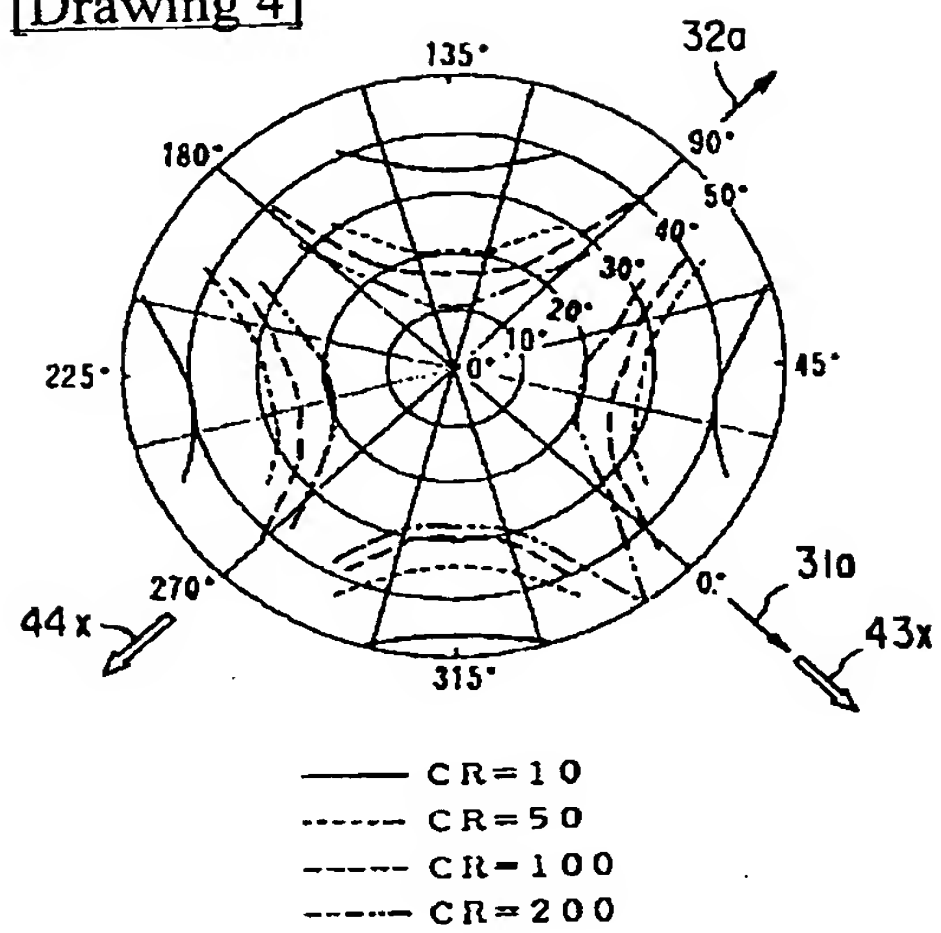
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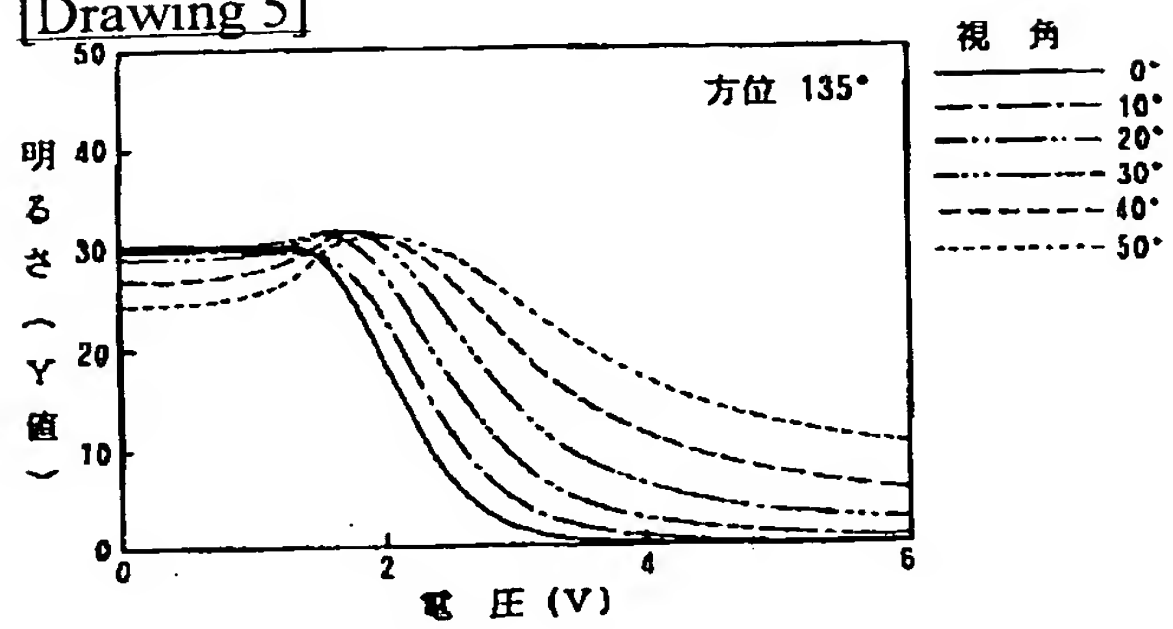
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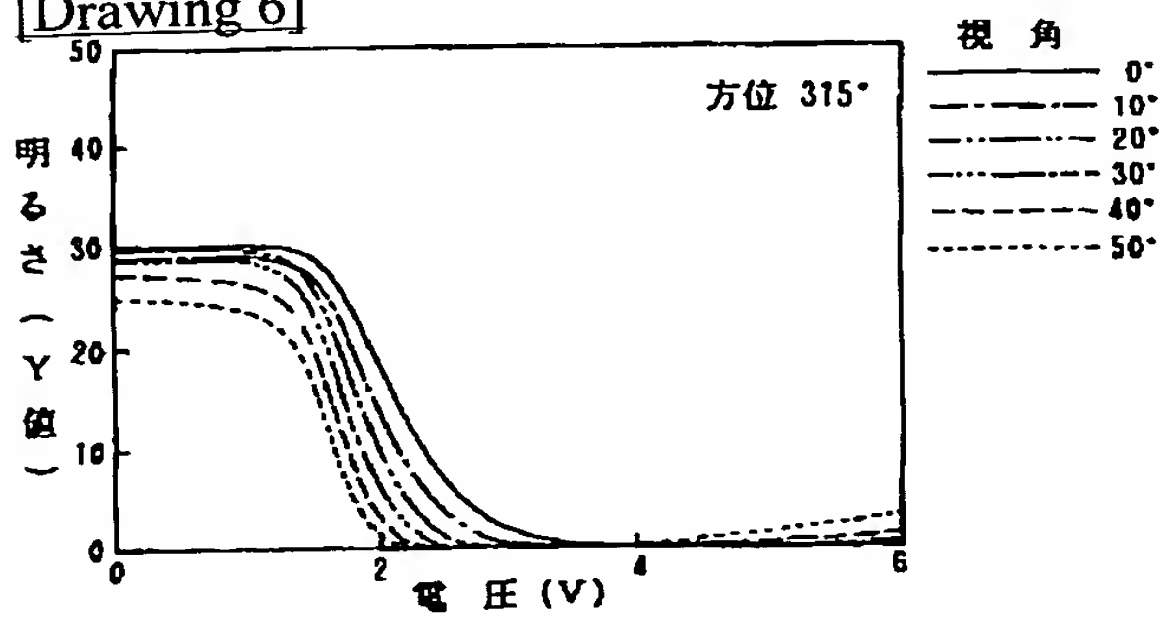
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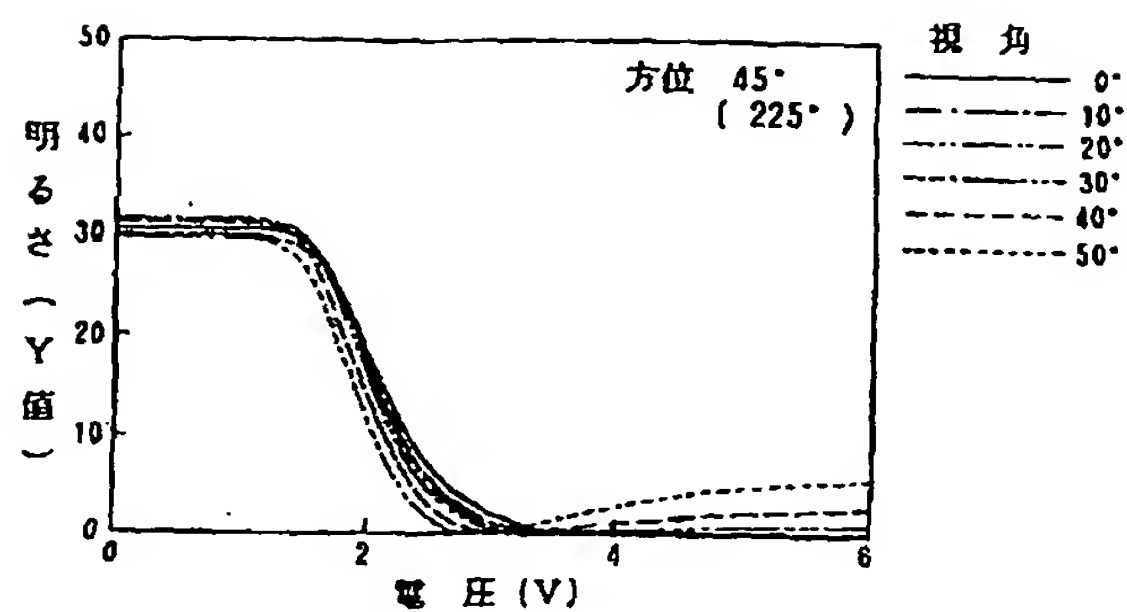
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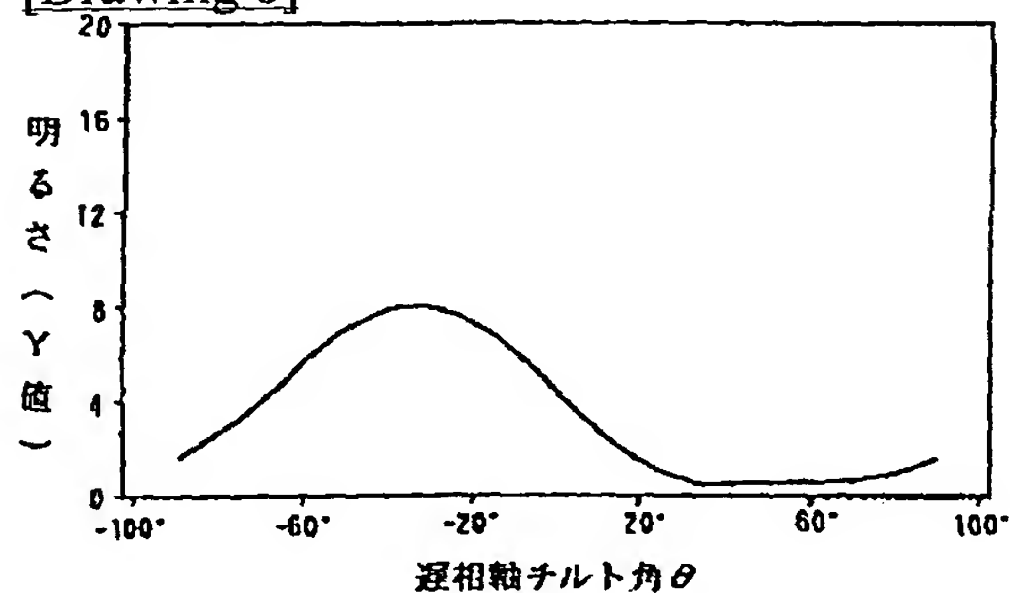
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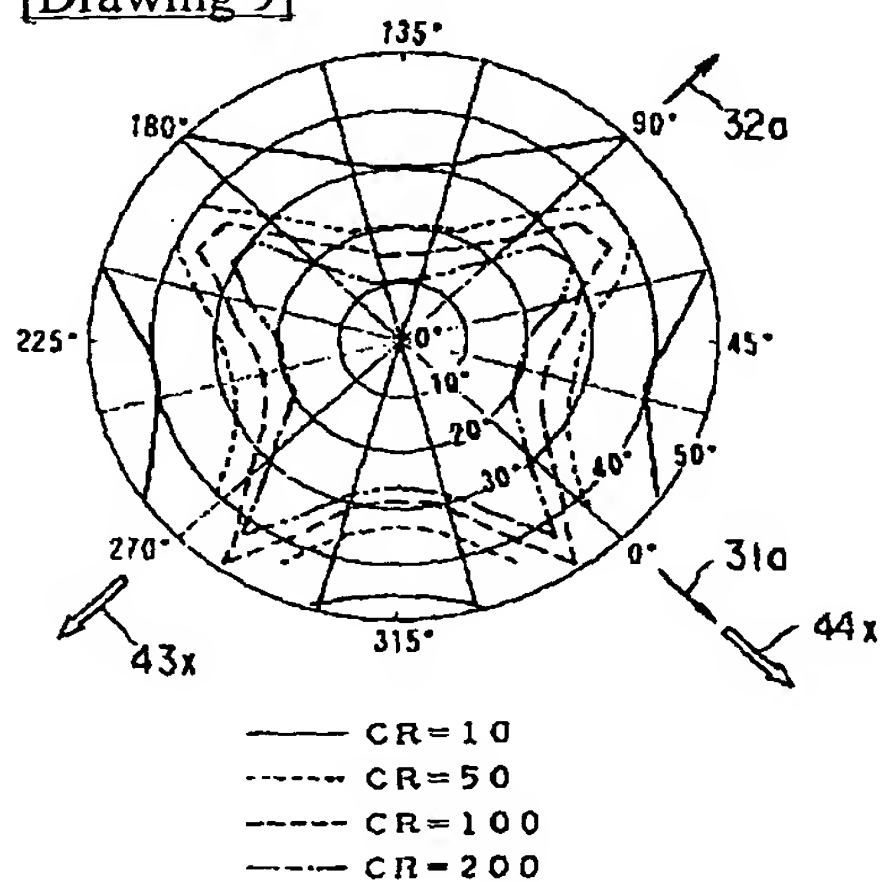
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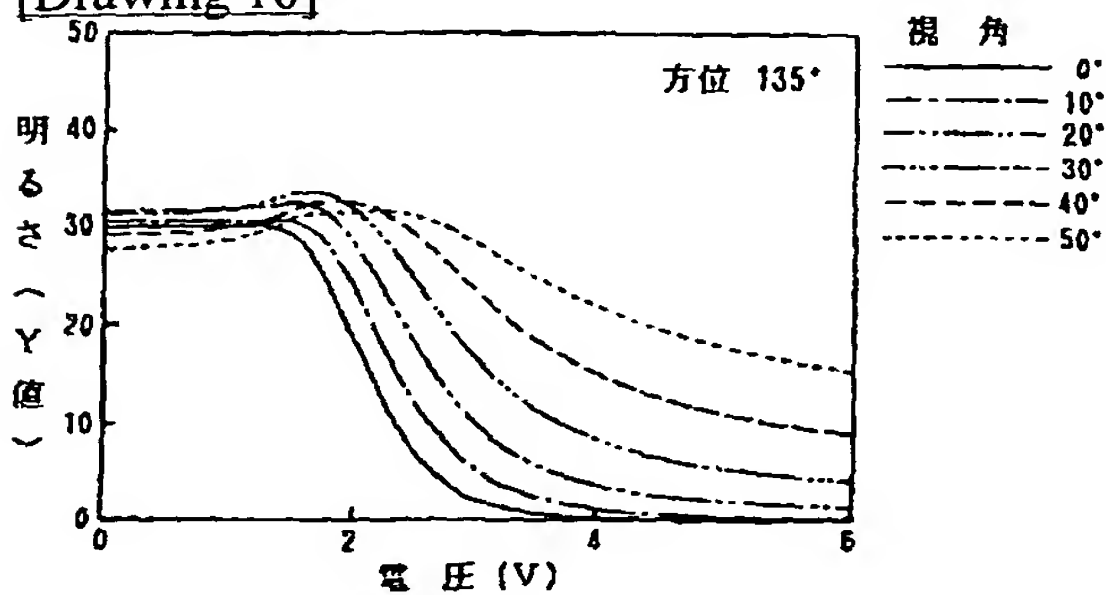
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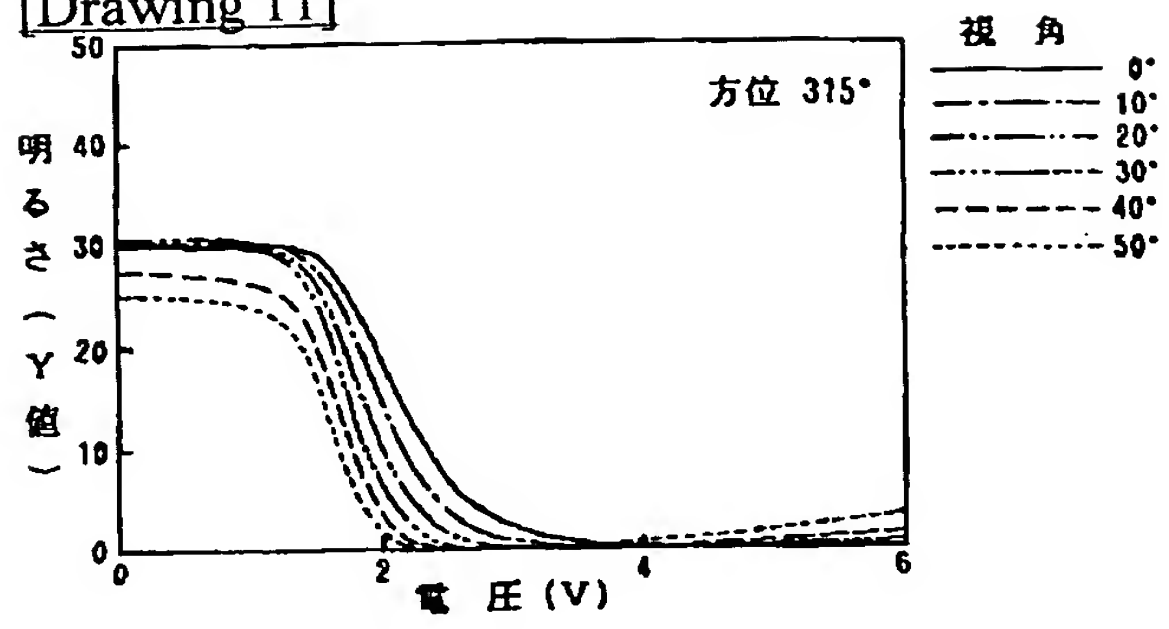
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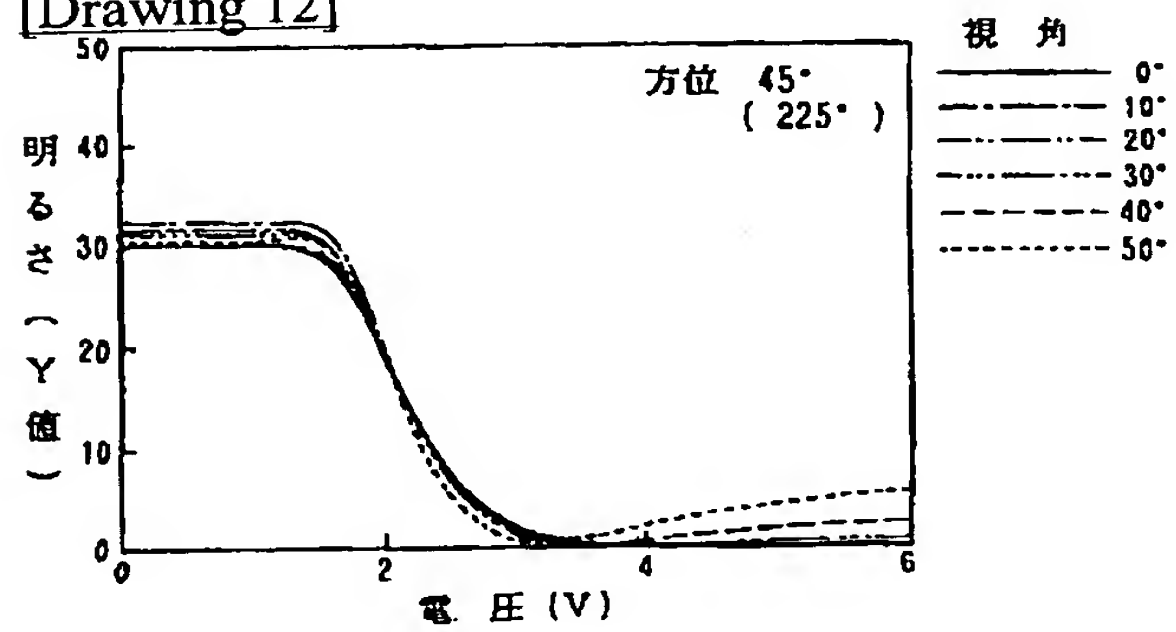
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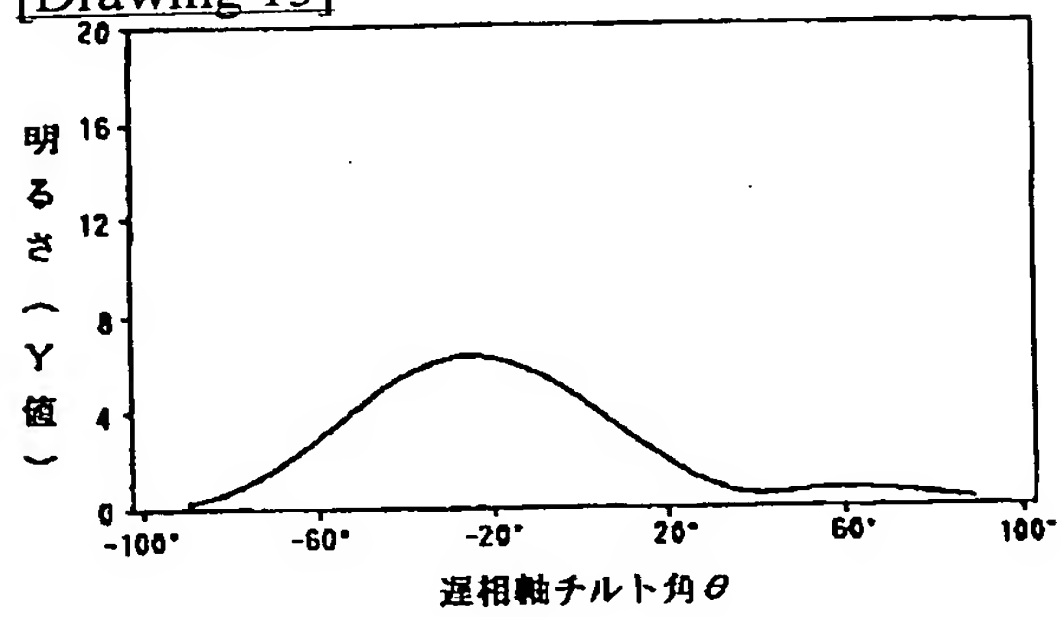
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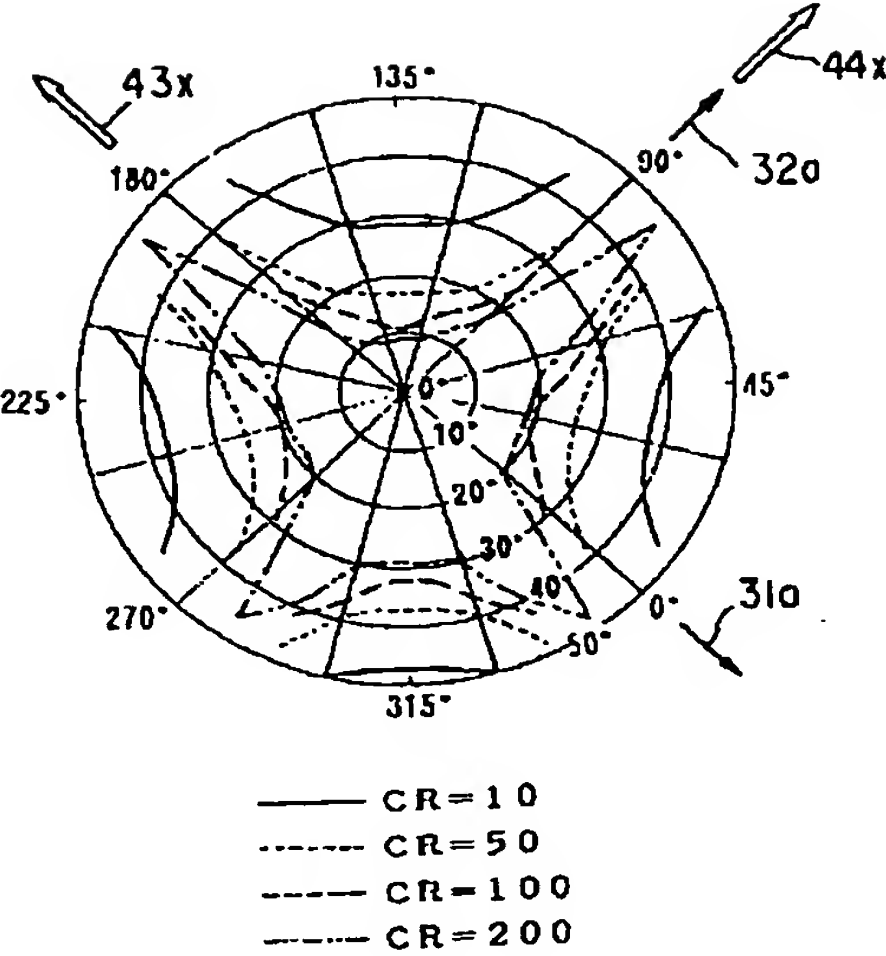
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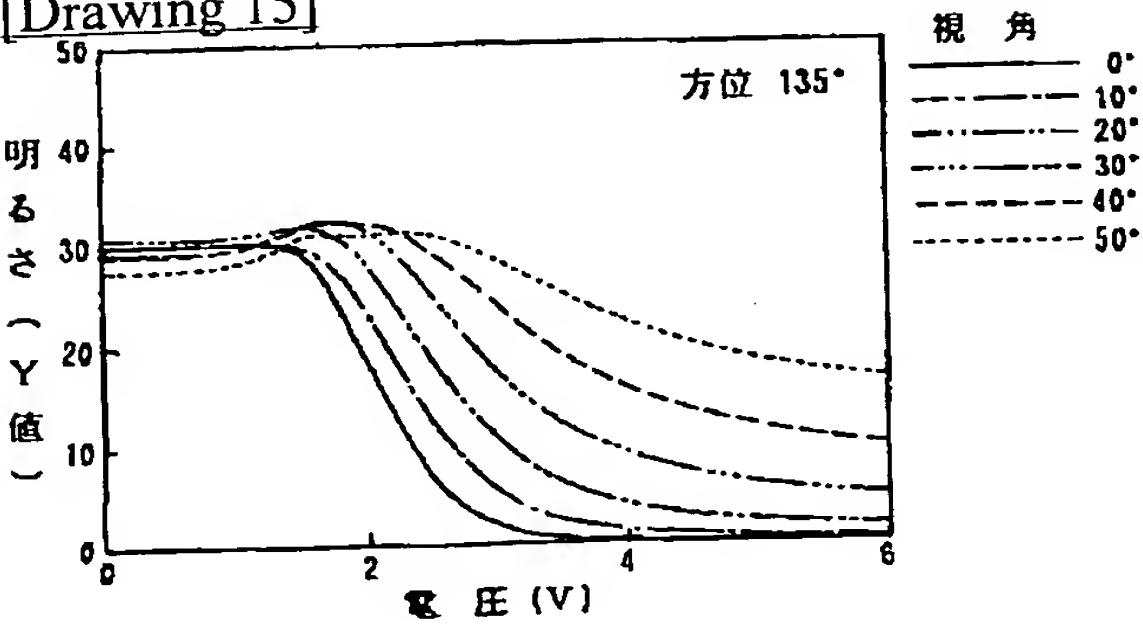
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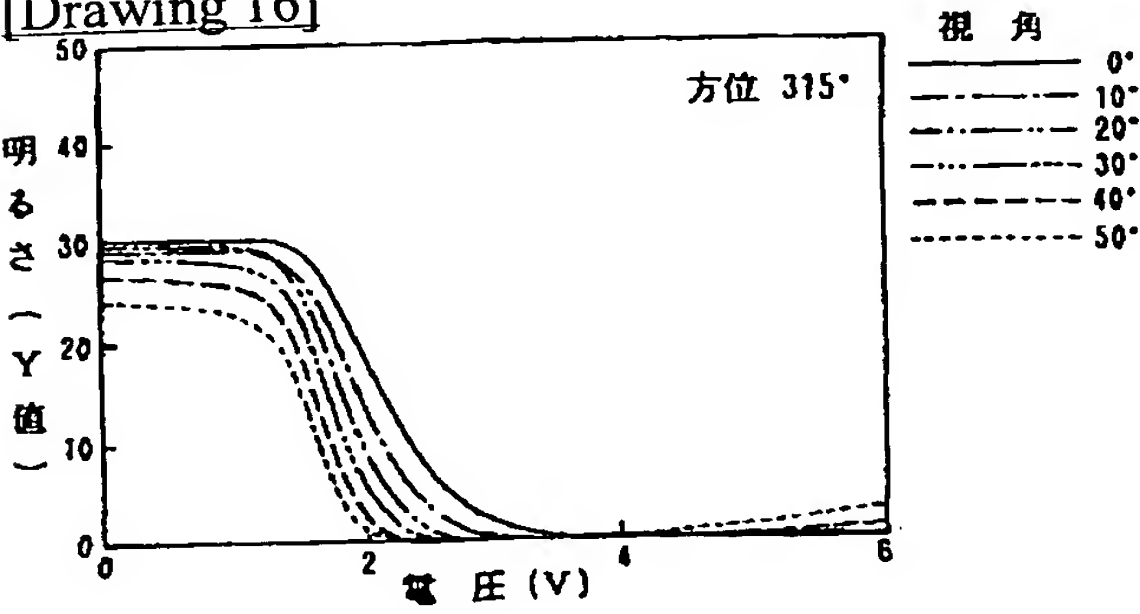
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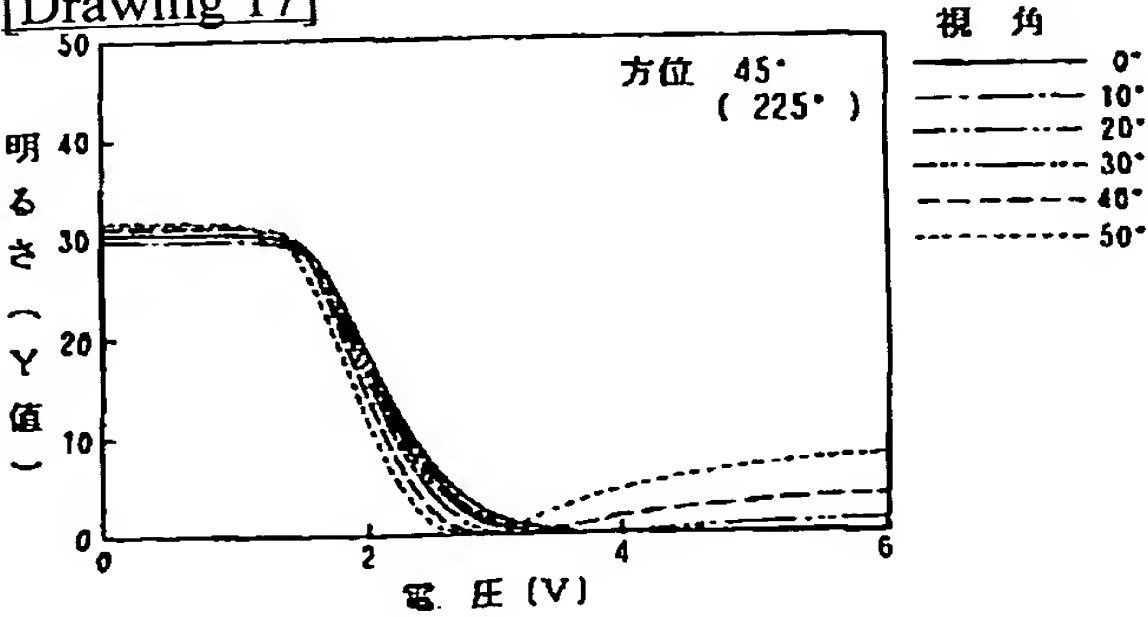
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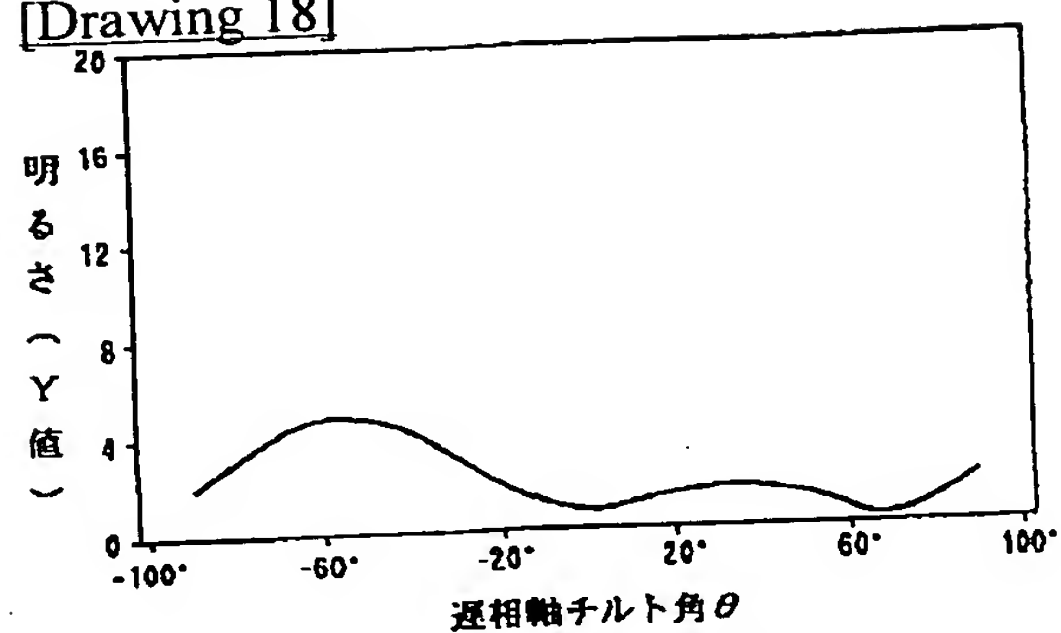
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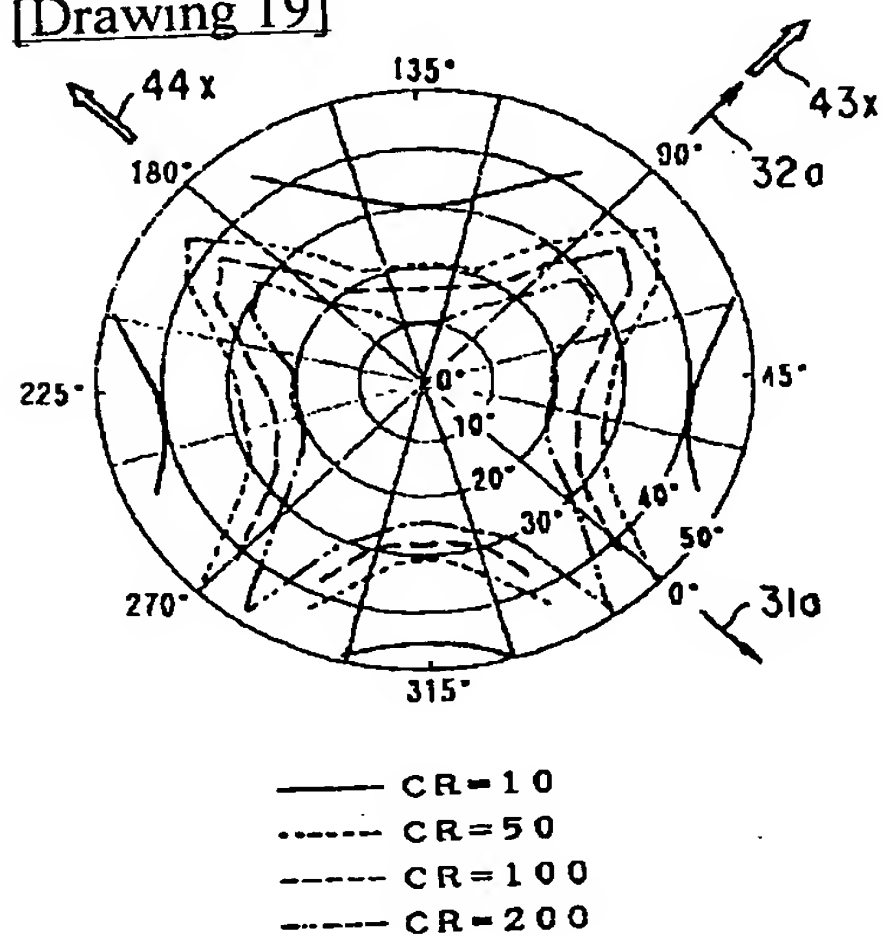
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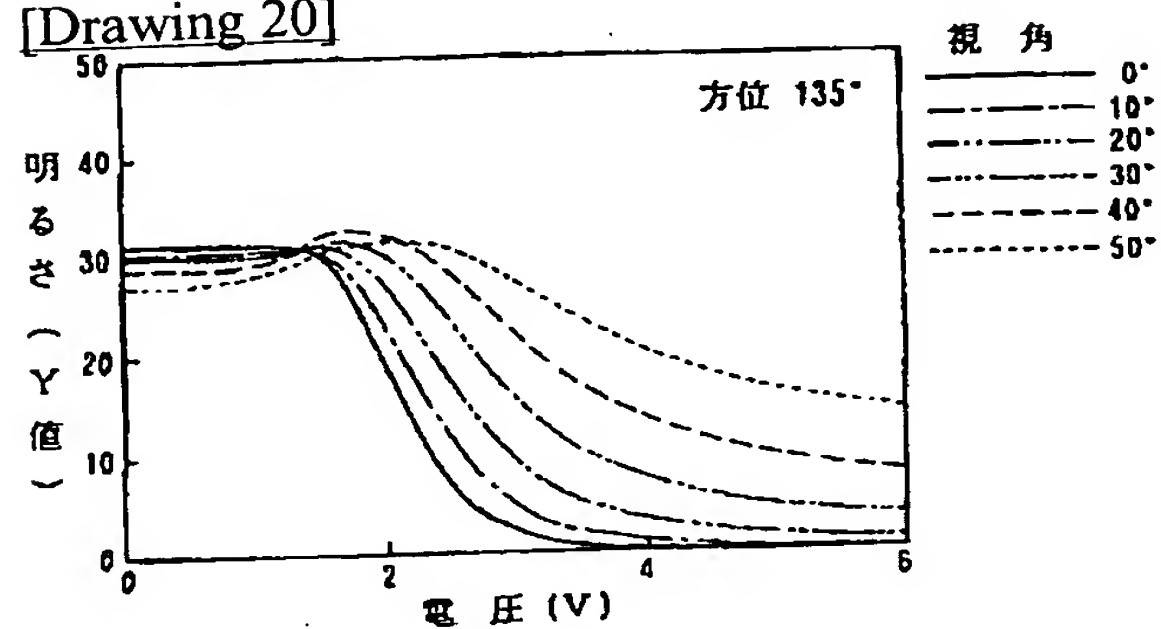
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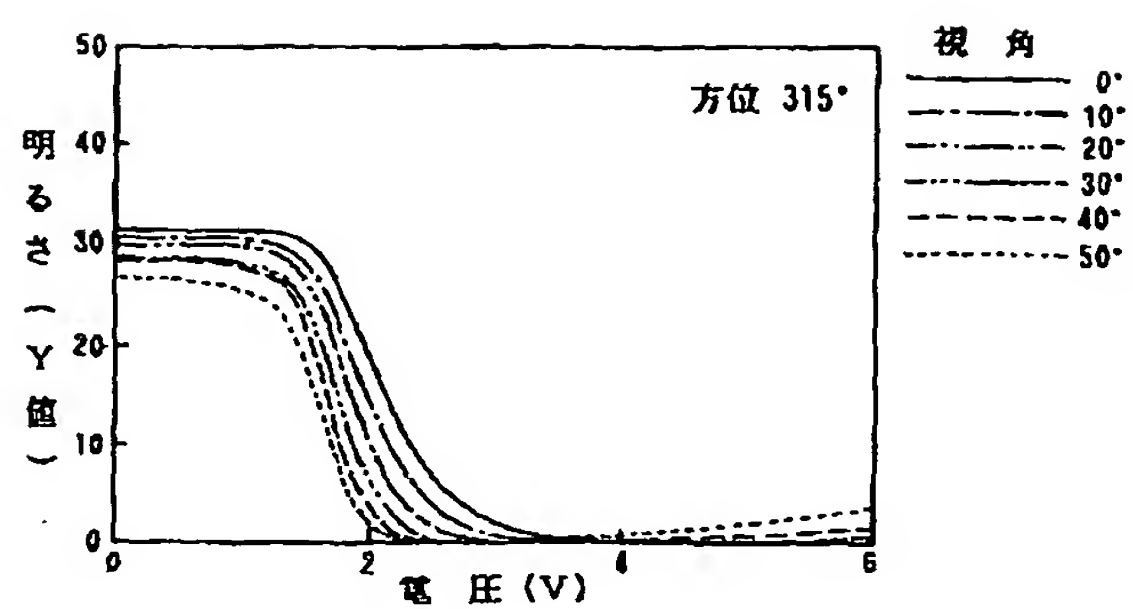
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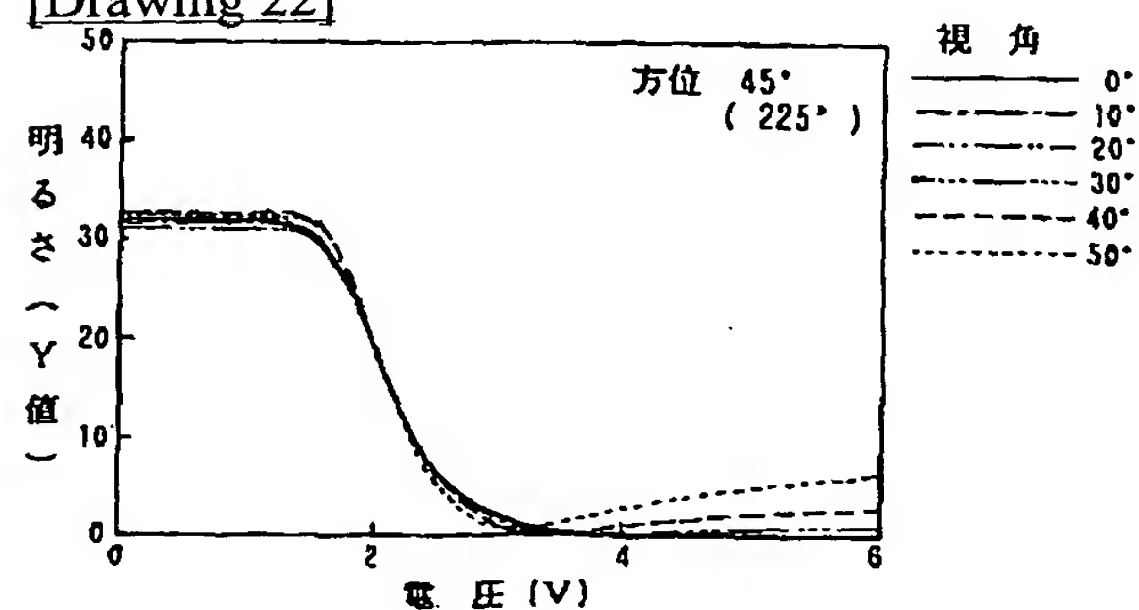
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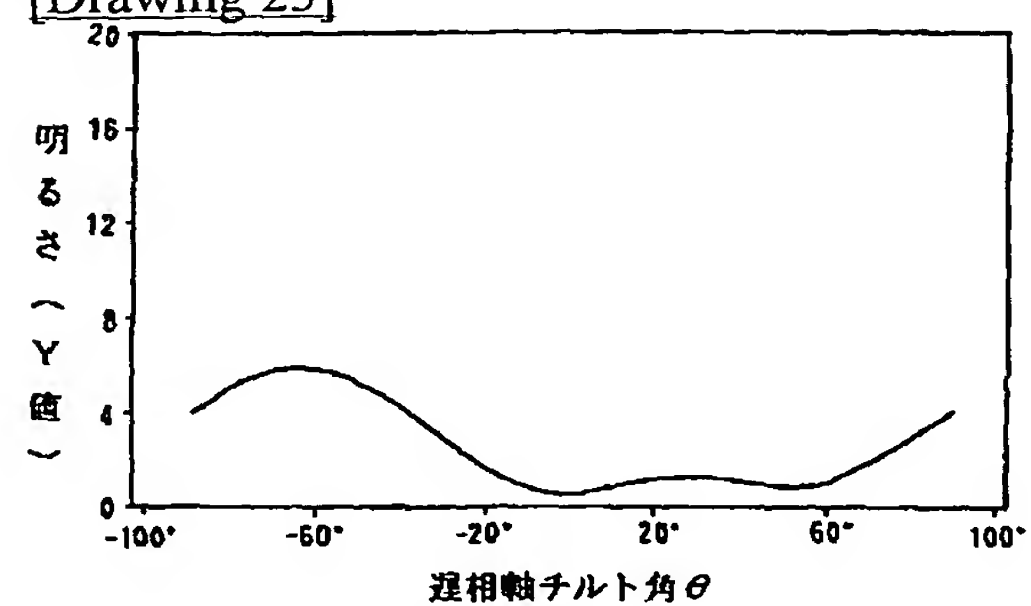
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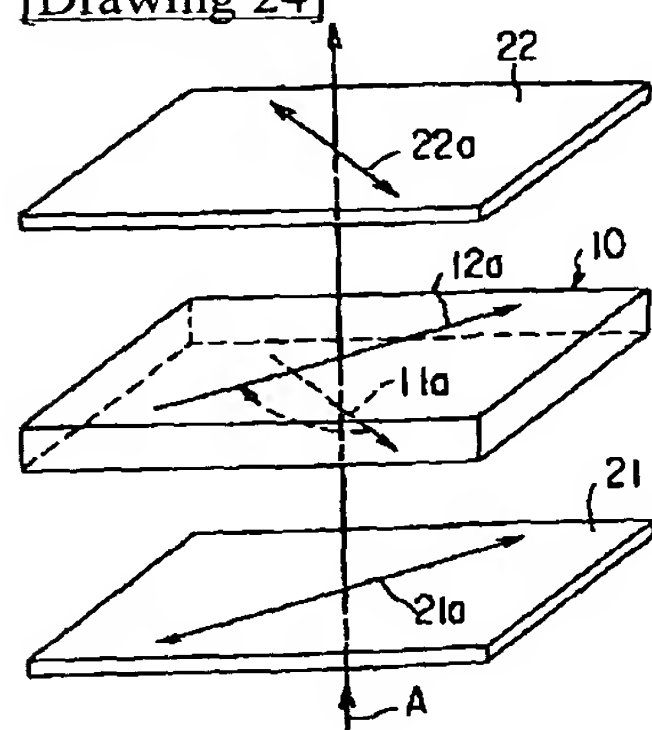
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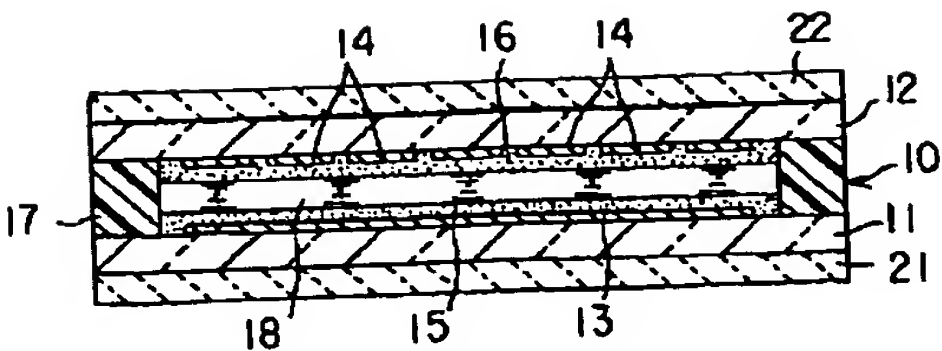
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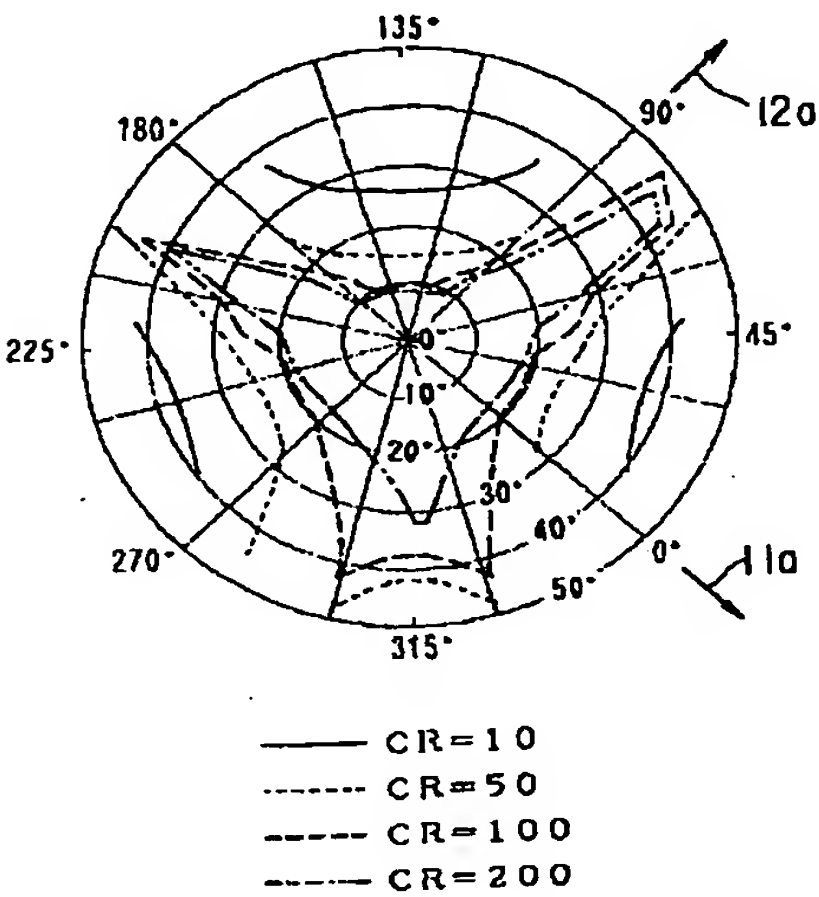
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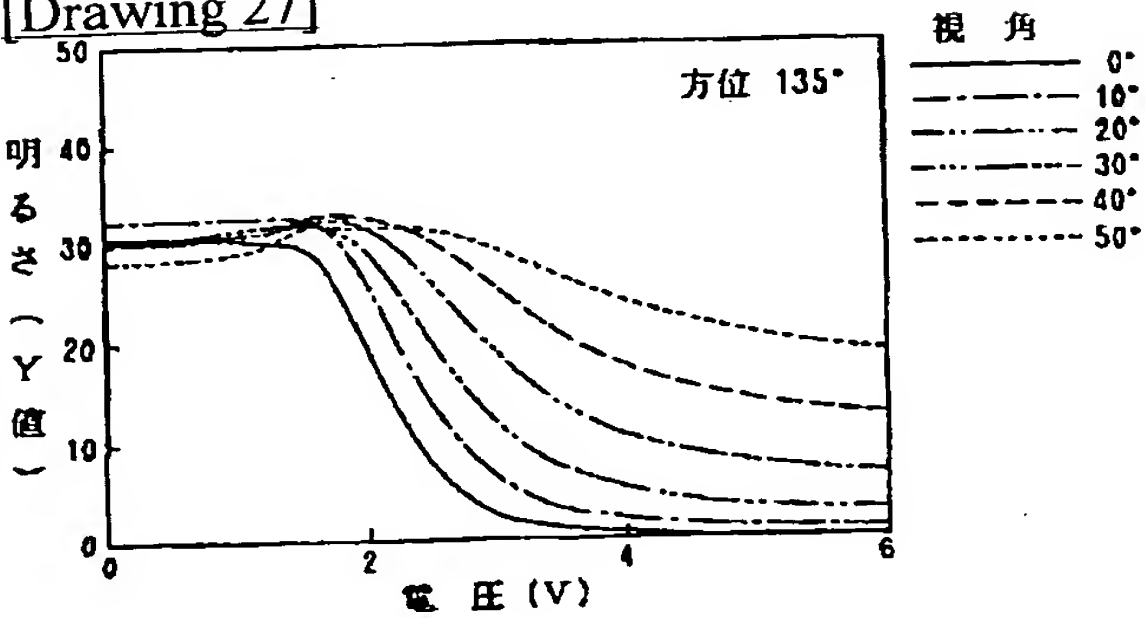
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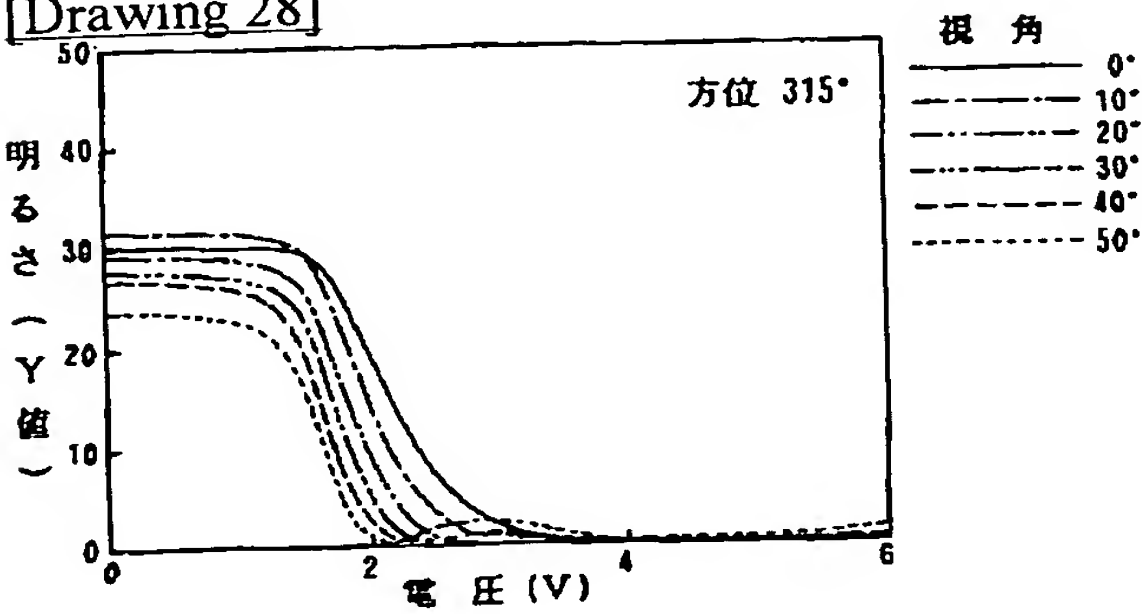
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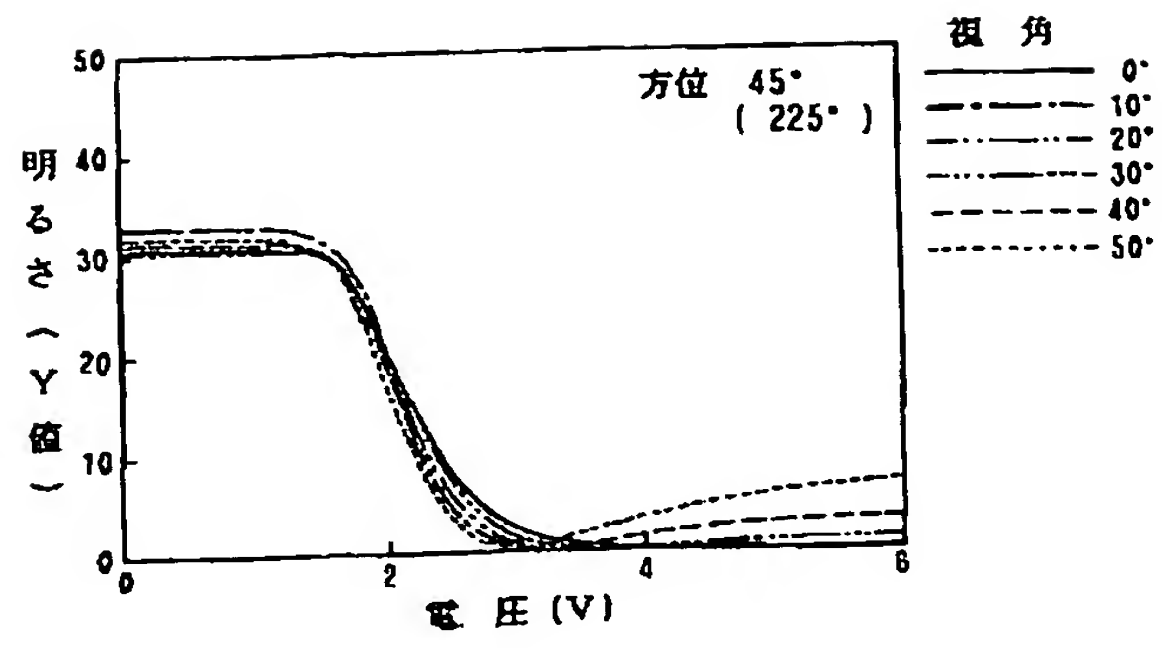
[Drawing 27]



[Drawing 28]



[Drawing 29]



[Translation done.]